

INTERNATIONAL INSTITUTE OF AGRICULTURE
BUREAU OF AGRICULTURAL INTELLIGENCE AND PLANT DISEASES

INTERNATIONAL REVIEW OF THE SCIENCE
AND PRACTICE OF AGRICULTURE
MONTHLY BULLETIN
OF AGRICULTURAL INTELLIGENCE AND PLANT DISEASES

FIRST PART
ORIGINAL ARTICLES

Problems of Cotton Growing (1)

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On the eve of the international cotton Conference which will be held at Rio de Janeiro in October, it may be useful to give certain information corroborated by biological and statistical data, regarding some of the more important fundamental questions relating to cotton growing.

This article is divided into three chapters; in the 1st the present possibilities of developing the growth are examined; the 2nd is devoted to the study of the seed, and in the 3rd a rapid survey is made of the diseases which injure, and often destroy this important crop.

I. -- PRESENT POSSIBILITIES OF DEVELOPING
THE GROWTH OF COTTON.

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- (3) DE CAMPOS, D., *Rapport sur la statistique du coton présenté à l'Assemblée Générale du Comité Permanent, Inst. Intern. d'Agric.*, VIth Assemblée Générale, May 8, 1922, p. 8, pp. 9-10. Rome, 1922.
- (4) RICCI, U., *La Conférence cotonnière mondiale de Liverpool et Manchester. Rapport*, XI. *Intern. d'Agric.* VIth Assemblée Générale, May 6, 1922, No. 8-A, pp. 10-11. Rome, 1922.
- (5) *Les pays cotonniers. Leur production et leur mouvement commercial. Inst. Intern. d'Agric.* *Revue de la Statistique générale*. Rome, 1922, p. 91 (Érythrée), p. 103 (Somalie italienne).
- (6) *Id.*, *id.*, pp. 122-123.

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- (7) *Bulletin of the Imperial Institute*, Vol. XIX, No. 2, pp. 160-170. London, 1921.
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 (9) Other important information on the cotton problem will be found in :—
 TODD, J. A., *The World's Cotton Crops*, ch. XIV, pp. 1-460 with illustrations, maps and diagrams, London, 1915.
 GOULDING, R., *Cotton and Other Vegetable Fibres; their Production and Utilization*, pp. 1-97. London, 1917.

If the statistics of the cotton production of the world are examined, it is seen that, on the whole, it has decreased chiefly owing to a decline in the United States yield.

The data published in the *Annuaire International de Statistique Agricole* from 1909 to 1921, give the following totals for the different parts of the world (Table I).

TABLE I. — *Total production of cotton in the world from 1909 to 1922.*

Regions	Area (ha).			Production of ginned cotton (qx.)		
	1909-10 to 1913-19	1914-15 to 1918-19	1919-20 to 1921-22	1909-10 to 1913-14	1914-15 to 1918-19	1919-20 to 1921-22
Europe	10 224	9 884	11 878	30 116	22 003	25 839
North and Central America	13 928 268	14 087 255	13 686 822	28 706 594	27 267 137	24 334 734
Asia	9 187 086	9 052 552	8 691 854	7 863 226	7 939 332	8 643 176
North Africa	759 816	732 577	775 656	3 229 074	2 550 543	2 383 939
South America	272 174	309 533	476 809	879 097	977 300	1 440 637
South Africa	26 045	27 366	25 789	28 671	21 483	20 302
Oceania	150	45	3 140	163	72	735
<i>Grand Total</i>	24 183 763	24 219 212	23 671 948	40 730 941	38 786 870	36 849 315

Table I, which gives the averages of these recent years, shows also that the decrease in the area cultivated, which in round numbers is about one and a half million hectares, does not correspond with the decrease in production, which exceeds four million quintals; the latter being much greater in comparison with the decrease of the area cultivated, since according to Table II in the above-mentioned *Annuaire* the average of production per hectare varies between 1.6 q. and 1.7 q. Other causes have therefore influenced this decrease, which will be examined later in considering certain fundamental questions in the world's cotton problem.

If the figures relating to the statistics of the world's production in various countries are examined in detail, we see that there are at present three principal cotton centres in the world, all situated in the Northern hemisphere, namely :— the United States of America, which produced in 1909-10/1913-14, 28 258 194 qx., in 1914-15/1918-19, 26 937 344 qx., in 1919-20/1921-22, 23 994 679 qx.; British India, with the following pro-

duction :— in 1909-10/1913-14, 7 770 220 qx., in 1914-15/1918-19, 7 785 099 qx., in 1919-20/1921-22, 8 391 671 qx. ; Egypt, with the following production :— in 1909-10/1913-14, 3 149 782 qx., in 1914-15/1918-19, 2 462 037 qx. in 1919-20/1921-22, 2 232 576 qx.

Brazil, chiefly in the Southern hemisphere comes next with :—

1919-20 — 1913-14	611 900 qx.
1914-15 — 1918-19	675 460 "
1919-20 — 1920-22	1 045 304 "

Regarding the yield per hectare, which is a very important coefficient, it is given, according to the above-mentioned *Annuaire*, for a number of countries in Table II (p. 930).

These figures are very important, because they show that, except in Peru, where the average production per hectare is the highest, Egypt and Japan, where the averages always exceed 3 qx. per hectare, in the other countries (including the United States which is the greatest cotton centre in the world), the averages are very low and in certain countries almost negligible. These figures indicate that the chief cotton region of the Northern hemisphere is Egypt where the averages always exceed 4 qx. and often 4 qx. per hectare ; while in the Southern hemisphere, the averages reach and exceed 3 qx. per hectare in South America. The Southern hemisphere has higher averages than the Northern hemisphere, indeed almost double.

Apart from the decrease in the total area cultivated, the decrease of the world's cotton production is due also generally to the almost continuous decrease in the production of cotton per hectare, which is shewn in Table II.

* *

The above paragraphs give the present position of the world's cotton production and the question of the future possibilities of development ext arises.

In certain countries, such as Brazil, in certain central and eastern parts of Africa and in certain parts of Asia, the production of cotton is susceptible of great extension and probably this is the case for China, Manchuria and Korea.

J. A. TODD in a very interesting article published in a recent number of *The Agricultural Journal of India*, recognises that Brazil is a very important centre of cotton production capable of very great development. Further, it should not be forgotten that the *International Federation of Master Cotton Spinners* has recently sent representatives to Brazil to investigate and study on the spot the possibilities of cotton production ; and that this mission, which is composed of members of unquestionable authority, has recognised that Brazil possesses most favourable conditions of climate and soil for becoming a centre of cotton production. of the highest importance. It is certainly necessary that all measures calculated to encourage cotton planters as effectively as possible should be taken and that all modern

TABLE II. — Unitary production of cotton in the world from 1909 to 1922

Number	Country	Yield: quintals per hectare		
		1909-10 to 1913-14	1914-15 to 1917-19	1919-20 to 1921-22
1	Bulgaria	2.3	1.1	1.8
2	Greece	(1) 3.0	2.5 (1)	2.2
3	Malta	2.3	2.1	2.2
	Europe	2.9	2.2	2.1
4	Antigua	1.8	(2) 1.1 (1)	1.3
5	Barbados	1.4	1.3 (2)	1.0
6	United States	2.0	1.9	1.7
7	Grenada	—	(3) 1.0 (1)	1.3
8	Dutch West Indies	(4) 2.4	2.5 (1)	2.3
9	Jamaica	—	2.5	—
10	Mexico	—	—	—
11	Montserrat	1.7	1.7	1.8
12	St. Kitts and Nevis	1.6	1.5	1.5
13	St. Vincent	1.2	0.8	0.8
	North America	2.1	1.9	1.8
14	Cyprus	—	(1) 0.4	1.3
15	British India	0.9	0.9	1.0
16	Indo-China	—	(4) 1.1	—
17	Japan	3.6	4.1 (3)	3.9
18	Korea	0.9	1.2 (3)	1.5
	Asia	0.9	0.9	1.1
19	Algeria	—	—	—
20	Egypt	4.5	3.9	3.3
21	Uganda	2.1	1.0	1.4
22	Anglo-Egyptian Sudan	(4) 1.7	(1) 1.0 (3)	1.5
23	Togo (French zone)	(3) 0.4	0.3	0.5
	Africa	4.2	3.5	3.1
	Northern Hemisphere	1.7	1.6	1.5
24	Argentina	(4) 2.9	2.9 (3)	2.6
25	Brazil	(4) 3.0	(4) 2.9	2.8
26	Peru	—	4.3 (3)	5.3
	South America	3.2	3.2	3.0
27	Belgian Congo	—	(3) 0.3 (3)	0.3
28	Nyasaland	(4) 0.9	0.9 (3)	0.6
29	Tanganyika	(2) 1.9	— (1)	1.5
30	Union of South Africa	1.7	1.7 (3)	1.4
	Africa	1.1	0.8	0.8
31	Australia	1.0	1.4 (3)	1.5
	Southern Hemisphere	3.0	3.0	2.9
	General Averages	1.7	1.6	1.6

(1) One year only. — (2) Average of 3 years. — (3) Average of 2 years. — (4) Average of 4 years.

cultural methods directed towards industrialisation and high production should be introduced.

In the report presented by Dr. DE CAMPOS to the VIth General Assembly of the International Institute of Agriculture it is stated that in certain regions of Brazil, such as the State of São Paulo and in the North-East, there are very high unitary yields of cotton, which exceed the averages of any other country.

Local varieties are very important and have a great future. The variety Riqueza has a very fine fibre, strong, flexible and glossy. "Mocó" which can be grown very successfully in Seridó produces a fibre 30 mm. long and, in that region, the plant becomes perennial, producing bolls for 10-15 years, while in Egypt a somewhat similar species is annual, requiring more labour, and giving a smaller yield of fibre. Another important variety is "Rim de Boi": the herbaceous short stapled cotton plant has the advantage that it can be grown in places which are unsuitable for other species and that it develops very rapidly: thus, at Alarós and Sergipe, only 3 months elapse between planting and picking, while at Maranhão one month and a half is said to suffice.

In recent years the cotton production of Brazil has increased considerably, as the following statistics, taken from the previously mentioned *annuaire*, show. On the other hand it has decreased very much in other countries.

Years	Quintals
1915-16	611 900
1916-17	608 327
1917-18	747 154
1918-19	734 461
1919-20	832 971
1920-21	977 842
1921-22	1 326 000*

* The figures 1921-22 are approximate.

According to HIMBURY, quoted by Prof. RICCI in his report, there are distinct possibilities for the development of cotton growing in British colonies in Africa and especially in Nigeria, whence 16 000 bales (of 400 pounds each) were exported in 1920, and some day there may be a production of one million bales; in Uganda, a country where cotton was unknown years ago, the production was 53 000 bales in 1920 and anticipations for the future point to 500 000; in the Sudan 22 000 bales were obtained, and there is a possibility of favourable development up to 1 500 000. Together Great Britain might possibly obtain from these three colonies, after a lapse of years 3 million bales of 400 pounds, which would represent $\frac{1}{7}$ of the present total production of the whole world.

There are also certain possibilities for the development of cotton growing in Erythrea, in the districts situated on the Anglo-Egyptian frontier and along the coast; but it will be necessary to bring to a conclusion

the experiments in selection of some American varieties of the "American Upland" type, and especially of the variety "Triumph" and of some short stapled "Orleans" kinds which have given excellent results. Italian Somaliland, especially the region of middle Ouébi Schébé, where the Duke of the Abruzzi has started a large farm and extensive irrigation works are being carried out, contains plains where by means of irrigation cotton planting could be considerably developed.

Before the war the Russians were investigating the possibility of intensifying and extending the growth of cotton in Transcaucasus and in Turkestan.

The following figures have been quoted for Russia in Asia :—

Years	Quintals
1909-10	906 967
1910-11	1 500 787
1911-12	1 604 945
1912-13	1 134 225
1913-14	1 449 747
1914-15	1 574 695
1915-16	2 145 209

Unfortunately the present conditions exclude the possibility of any reliable forecasts or estimates.

In the United States, which is the greatest centre of world cotton, production has decreased, both on account of some reduction in area under cotton and of the significant decrease in the unitary yield. In fact from a maximum production of 34 983 423 qx. obtained in 1914-15 production went down to a minimum of 18 082 538 qx. in 1921-22.

The case of Egypt is similar and the decrease has been equally marked. Egyptian production reached its maximum in 1913-14 with 3 443 193 qx. and its minimum in 1921-22 with 1 482 624 qx. One of the principal causes of this decreased production in Egypt is to be found in infections, especially the "pink bollworm", while other contributory factors are want of manure, continuous cropping, and too long continued growth on the same ground and the state of the soil in relation to irrigation and drainage.

A region which may perhaps have some future for cotton planting, when the political problems and those of irrigation and labour have been solved, is Mesopotamia, where there is a possibility of utilising more than 121 000 ha., along the banks of the Tigris and the Euphrates. Experiments, undertaken by Capt. R. THOMAS in 1918 and continued in the following years, gave promise of eventual, good results.

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From this rapid examination the following conclusions may be drawn.

1) The growth of cotton in the different countries of the world is susceptible of substantially increased development, especially through

encouragement in those new countries in which conditions are particularly favourable.

2) The causes of the present decrease in the world's production of cotton are due to the decrease in the area cultivated and especially to the decrease in the unitary yield.

3) The decrease in yield is due to complex causes, among which are: — deterioration of the species grown in the absence of good selection methods, the still imperfect cultural methods followed in many regions and the insect pests which in certain countries destroy a large portion of the crops.

4) The unitary yield probably depends on a combination of geographical and ecological factors which require detailed study and exact determination in the interest of the world's future cotton production.

5) In cotton statistics, it is necessary to distinguish between the production of long stapled and short stapled species, the more so because, from the standpoint of manufacture and market prices, these two types of cotton may be considered in many respects as different products.

II. — THE PROBLEM OF SEED.

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- 6) *Bulletin de l'Union des Agriculteurs d'Égypte*, Vol. XVI, No. 24, pp. 153-179. Cairo, 1918.
- 7) Article on cotton in Egypt in *Bulletin of Agricultural Intelligence and Plant Diseases*, Vol. VI, No. 8, Aug. 1915.

Another problem of capital importance in the cotton question is that of seed. The success or comparative failure of cotton crops depends specially on the quality of the seed used.

The most serious fact which impairs both the quality and quantity of the product originates from the mixing of the seed which takes place during the operation of ginning the cotton. If the ginning machines are not perfectly cleaned, a small quantity of the seed of one variety remains, and gets mixed with the next variety. The impurity of the seed results in the mixture of varieties in the crop and, owing to the facility with which cotton plants cross-fertilise, considerable quantities of natural hybrids are produced which impair the homogeneity of the crop and the quality of the produce. This phenomenon is most evident in the

United States and is one of the principal causes of the deterioration of varieties of cotton plants and their low yield. An interesting study has been made on this subject in Texas by SAUNDERS and CARDON, and has shown that the mixture of seeds takes place in the case of the drum, of ginning machines, that the ginned seed contains not less than 14 to 16 % of seeds from the lot of cotton previously ginned and that it contains also a small percentage of the previous lot.

To avoid this mixing the ginning apparatus must be carefully cleaned before proceeding to gin each new lot; these precautions require longer time which slightly increases the cost of the operation, but the advantages obtained are well worth the expense and result in an improved cotton crop.

Selection carried out by scientific methods is of very great importance for improving the seed. Researches on this subject have been undertaken for many years in British India at the experimental agricultural stations of Akola, Sindnahi, Lyallpur, Mirpurkas and in Burma. These researches have for object the isolation of the most productive and most important types, from an agricultural standpoint, from the mixtures of forms which constitute the local varieties or types and also the study of those exotic species which are most suitable for growing. The results obtained should encourage perseverance in this line and also might serve as an example to other Governments to carry out similar investigation and research in their countries.

The work of selection by pure lines carried out by B. C. BUR and HAIDER NIZAMUDDIN at the Kaliempur Station (British Indies) and which deals with the type of acclimatised cotton plant known under the generic name of "Cawnpore American", may yield some important results: the quality and quantity of the produce in the selected forms have always been superior to that of the original mixtures and may open the way to further improvements.

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In Egypt, where the deterioration of cotton has been very marked in recent years, very searching investigations have been made regarding the causes of this deterioration which entails enormous economic injury to the country. The article by VICTOR MOSSEMI on this subject, seems to be most interesting; he notes in Egyptian cotton plants, not a true degeneration, but a deterioration due to essential and accidental causes which affect the quantity and quality of the produce. To remedy it, especially so far as quality is concerned, it is necessary to isolate and purify the cultivated types or to select the most suitable plants and shield them during propagation from all other pollination.

Three methods can be used for this object — the first, employed by BALLS at the Laboratory of the Khedivial Society of Agriculture, consists, after having isolated a type, in adding, by means of crossing and methodical elimination, the advantageous specific characters desired. This

is the *method of addition or synthesis*. The second consists in isolating the types which present the specific advantages desired, eliminating those which do not offer the advantage wished for, the *method of analysis or of elimination*. The third method is that of the *selection of advantageous mutations*.

The most difficult thing is to propagate the seeds of pure types and keep them free from all contamination, and this can be done by care when ginning; by not growing different varieties too near each other in order to avoid hybridisation; by eliminating undesirable plants from the plantation and by rigorous control of the seed. It is only in this way that the best Egyptian types can be saved from inevitable decadence.

This rapid study of cotton seed may be concluded by the following recommendations:—

- 1) That all cotton growing countries should carry out investigation and research on the genetics of local and imported species of cotton plants, following the methods used in India and Egypt, with the object of isolating the best pure lines.
- 2) That, as soon as these pure types are obtained and established, every effort should be made to keep them free from all degeneration, especially by avoiding the cultivation of various species in adjacent areas.
- 3) The greatest care and cleanliness should be used in ginning cotton for seed purposes so as to avoid the mixture of seeds of different varieties, which takes place, as has been clearly proved, in the ginning machines.

III. — DISEASES OF THE COTTON PLANT.

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See also the collection of *Monthly Bulletins of Agricultural Intelligence and Plant Diseases* of the International Institute of Agriculture which contain, under the heading *Plant Diseases*, much information on the diseases of the cotton plant and their remedies.

The cotton plant, like all cultivated plants, is subject to numerous diseases, some of which are very destructive to the crop. These diseases may be grouped in 3 classes:— The first includes those which are due to physiological causes, the second deals with diseases due to vegetable parasites, the third includes all diseases caused by animals, especially by insects.

(A) DISEASES DUE TO PHYSIOLOGICAL CAUSES.

(a) "Mosaic disease or Yellow leaf blight". — This is characterised by yellow spots which are arranged more or less regularly on the surface of the leaves and cause withering and fall of the leaves. This disease

is often aggravated by the simultaneous attack of some fungus. It is due to the weak constitution of the plants attacked and the remedy lies in better cultivation such as the addition of kainit to the soil, which is always beneficial.

(b) "Red Leaf Blight". — This is shown by a red margin of the leaves; the growth of the plant is gradually arrested and the leaves fall. This disease is due to scarcity of some fertilising elements of the soil and can be controlled by means of manures, in order to supply the elements which are lacking (potash, nitrogen and phosphoric acid).

(c) "Shedding of Bolls". — Disease due to unfavourable climatic conditions and which is frequently noticed during periods of drought or excessive rain.

(B) DISEASES OF CRYPTOGAMIC ORIGIN.

(a) "Anthracnose". — This disease is caused by *Colletotrichum Gossypii*, and it attacks the stems and the leaves. No direct remedies against this disease are known: phosphate and potassic manures render the plants more resistant to attack. Where the disease has shown itself, all the refuse remaining in the field after the harvest should be collected and burnt and cotton should not be grown there in the following year.

(b) "Wilt or Trenching" is produced by *Neocosmospora vasinfecta*: the fungus enters the plant by its roots and gradually invades the whole vegetative system. The first indication of the disease is the turning yellow of the under part of the lowest leaves. On examination of the stem after breaking, it will be seen that the fibrovascular bundles are dark brown. The only remedy for this disease is selection, which enables resistant varieties to be obtained; in the United States the "Sea Island" cotton industry which was threatened with extinction, has been saved by this method.

(c) "Root Rot" is due to a species of *Ozonium*, a fungus which also attacks other plants besides cotton, such as lucerne, apple trees etc. The fungus attacks the roots and lives on the soil at the expense of the plant. The only means of control is a scientific rotation, by following cotton crops with cereals which are resistant to this disease; cotton should not be grown for three or four years on land where the disease has shown itself.

(d) "Cotton Leaf Blight". This is the most common disease of the cotton plant. The fungus (*Sphaerella gossypina*) usually attacks the oldest leaves and predisposes the plant to attacks by other diseases, particularly "Mosaic disease". The infected leaves are characterised by spots, white or light brown in the centre and reddish on the edges.

(e) "Cotton Mildew". Due to *Ramularia areola*, this disease shows itself on the leaves by small zones bordered by marbling.

(f) Angular Leaf Spot:— The disease is shown by dark angular spots on the leaves of the less vigorous plants; good cultivation is the best means of prevention.

Heteroderma radicola causes swellings on the roots and diseases of bacterial origin also attack the cotton plant.

(C) DISEASES OF ANIMAL ORIGIN.

(a) "Cotton Boll Weevil" (*Anthonomus grandis*). This is the greatest enemy of cotton crop. This beetle, a native of Mexico was reported in 1892 in Southern Texas, and has spread to such an extent that it has invaded almost the whole cotton growing area, and causes enormous damage. The eggs are laid in spring on the flower buds or on the young capsules; the larvae feed on these parts of the plant and the insect multiplies so rapidly that five generations occur between the 1st May and the 1st December. Control by means of its natural enemies has been tried, among which are some hymenoptera (*Ectatomma tuberculatum*, *Braccon mellitor*, *Cotolaccus incertus*, *Eurytoma tylodermatis*, etc.). DWIGHT PIERCE has tried to limit the development by placing beside it other anthonomes but with little result.

Insecticides, arseniate of lead among others, have proved ineffective. The best means of control is to prevent the normal evolution of the species by adopting the following measures:— (1) selection of varieties which ripen very early; (2) sow as early as possible; (3) hasten growth by all means. Furthermore, as the insect hibernates on the leaves and on debris of the soil, they should be burnt. Rotation also decreases the damage. In zones with a dry climate (East Texas, California, etc.) the plant is protected to some extent from the attacks of the "boll weevil".

(b) "Cotton Boll Worm" or capsule worm. This is the larva of a micro-lepidopter (*Heliothis armigera* or *Noctua armigera*) which is very common and feeds on the leaves, flowers and capsules of the cotton plant and causes great damage. As it also attacks other plant, it is recommended to sow catch-crops, especially maize sown late in the middle of the cotton fields to attract the insect at the time when the larvae develop. Insecticides made with Paris green and arseniate of lead have given good results. In Egypt the "Cotton boll worm" is the larva of *Earias insulana*, which behaves like the former and causes enormous damage; it also attacks hemp and *Hibiscus esculentus* (gombo, chiudi) which is used in India as a trap-crop. An analogous species (*Earias fabia*) has been noticed in Egypt, India, Ceylon and Java.

The "Egyptian Boll Worm" is *Prodenia littoralis*.

(c) "Pink Boll Worm" or "small boll worm" is the larva of another micro-lepidopter very common in Europe, Asia and Africa (*Gelechia gossypiella*) which causes such great damage to cotton plantations that it destroys them completely, as has happened in India and in Egypt, where it is one of the causes of the decadence of cotton growing. The capsules attacked should be carefully collected and burnt; the use of lamps to attract and capture the insect, which is nocturnal, also gives good results. To destroy the larvae in the seed, which is the principal cause of propagation of the disease, the following methods may be employed:

1) treatment of the seed with hot air at 80° C; (2) fumigation with bisulphide of carbon or hydrocyanic acid or sulphurous anhydride; (3) immersion for 24 hours in a 0.1 % solution of "cyllin".

(d) "Cotton Worm" (*Alabama argillacea*) is another micro-lepidopter whose larva is a troublesome enemy of the cotton plant in the South of the United States and in the West Indies. This larva first attacks the topmost leaves and then descends towards the base of the plant destroying everything in its course, including young buds, flowers and young capsules.

In the United States good results have been obtained from an insecticide composed of powdered arseniate of lead mixed with Paris green, slaked lime and flour. In the West Indies the larva is destroyed by a wasp (*Polistes annularis* or "Jack Spaniard").

The "Leaf Roller" of different cotton countries is *Sylepta derogata*.

(e) "Cutworms" are the larvae of certain insects (*Feltia* sp., *Agrotis ypsilon*, etc.), which attack the young cotton plants after the germination of the seed. The best means of control is to place poisoned cabbage leaves in the infected plantations.

(f) "Cotton Aphis". This is *Aphis gossypii* which attacks a large number of young plants and the buds. The best remedy is the use of emulsions of soap and creoline.

(g) "Cotton Stainers". The worst are:— *Dysdercus* (the American "red bug") and the *Pentatoma* (*P. ligata*), the "conchuola" of Mexican planters.

Locusts also cause much damage to cotton plantations.

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As is seen from this brief review, the diseases of the cotton plant are many and often very serious. To control them it is indispensable to take international and national measures. These measures should prohibit the transport of seed of infected regions, unless disinfected and carefully controlled, into regions free from disease; methods of control should be studied and the most resistant types should be selected. It has been proved, for instance, that the resistance of Indian cotton plants to certain parasites is due to abundant resinous secretions which cover the valves of the capsules. This course, namely the study of types resistant to and free from disease, which has already given such excellent results with cereals for resistance to rust, will give important results provided that the investigations are undertaken with adequate means and a clear idea of the ends to be attained.

SECOND PART A B S T R A C T S

AGRICULTURAL INTELLIGENCE

CROPS AND CULTIVATION

798 - **Phenological Observations in Holland in 1921.** — Bos, H., in *Cultura*, Year 34, No. 400, pp. 2-13. Tiel, Jan. 1922.

Results of observations made in 1921 at the stations organised by the writer in Holland. Noticeable points:—

(1) The great abundance of flower buds of the ash (*Fraxinus excelsior*);

(2) The severe frost (-7° C) of 15th-16th April which damaged the flowering of cherry and pear trees and destroyed the shoots of acacias and plane trees;

(3) The early flowering and ripening, 10 days earlier than usual, of autumn rye;

(4) The severe drought in spring-summer caused a series of interesting phenomena: — there was a partial fall of leaves in the summer, followed, in certain plants (*Syringa*, *Aesculus*, etc.) by a fresh foliation and flowering; pear and apple trees blossomed for the second time at the end of June and commencement of July, and produced, generally, fruit half the size of normal fruits, but which in some cases attained remarkable size; most of them had no pips.

The drought also caused the leaves to turn yellow and wither, but this phenomenon should not be considered as an anticipation of the normal process of fading and fall in autumn. This process in fact, took place as usual in autumn, but notably late, due, according to the writer, to excessive exposure to the sun.

G. A.

799 - **Data regarding the Distribution and Intensity of Hail in Bulgaria.** — GRIGOROV, G. in *Semledelie*, year XXV, part 8, pp. 121-122. Sofia, Aug. 1921.

Data collected during the decennial period 1911-1920 warrant the statement that the greater part of Bulgarian territory is subject to frequent and severe hailstorms. The phenomenon has an essentially local character; cases however of extensive hailstorms, such as that of the 18th June, 1915, which raged over 164 communes, are not lacking. In most

[Abstract No. 798-799]

Distribution of hail in Bulgaria.

Year	Date of the first hail	Date of the last hail	Duration of the hail season	Maximum quantity of hail		Number of days on which hail fell	Number of Communes in which hail fell					
				Date on which it fell	Number of communes in which hail fell		Total	Once	Twice	Thrice	Four times	Five times or more
1911	3 III	27 IX	200	15 VI	15	29	108	89	16	3	—	—
1917	27 IV	27 IX	154	9 VII	52	39	281	232	38	8	2	1
1913	22 IV	1 IX	131	10 VI	70	55	352	264	61	17	8	4
1914	3 V	9 IX	130	3 VI	90	63	441	315	94	23	5	4
1915	14 IV	23 IX	162	18 VI	164	60	455	328	81	36	6	4
1916	25 IV	23 IX	151	13 VI	93	65	470	358	148	43	13	9
1917	19 IV	30 VIII	134	18 VII	60	49	281	227	47	5	2	—
1918	23 IV	10 IX	141	27 VII	57	47	369	302	54	11	2	—
1919	9 IV	18 X	193	25 VII	43	54	322	257	50	11	3	1
1920	24 IV	7 IX	137	19 VII	49	54	316	245	44	17	8	2

cases the hail clouds come from the west or north-west, and the phenomenon ordinarily is seen between 2 p. m. and 6 p. m.; it is very rare in the morning, the evening and at night.

The annexed Table contains the following data:— 1) duration of the hail season; 2) number of days on which hail fell; 3) number of communes in which hail fell, on the average, once, twice, or more often.

During the period dealt with, the duration of the hail season was 154 days (5 months). There were, on the average, 52 days of hail, and hail fell in 340 communes or 26 $\frac{3}{4}$ % of the insured communities. The co-operative Bank had to indemnify 18 % of the insured (47 166) and pay 17 997 416 lei (9 $\frac{33}{64}$ pence at par). G. A.

800 - **The Soil Fauna of Agricultural Land.** — BUCKLE, P. (Department of Agricultural Entomology, Victoria University of Manchester), in *The Annals of Applied Biology*, Vol. 8, Nos. 3-4, pp. 135-145, bibliography of 10 works. London, November 1921.

It is well known that cultivation has a detrimental effect upon the soil fauna, and various cultural operations are strongly advocated as preventive and remedial measures against the depredations of soil insects. However, it is not known whether arable land possesses a characteristic fauna apart from species peculiar to certain crops.

Hence, the survey was carried out on three types of agricultural land and the author studied the fauna of: a) land continuously under the plough for a number of years; since 1916, the rotation of crops included oats, potatoes, turnips and mangels and wheat; a dressing of farm-yard manure was given preparatory to the root-crop; 2) pasture land that had been broken up not less than three years previously; 3) permanent pasture, or meadow-land. The author gives all the characters of these

three types. In studying the fauna, 9-inch cube samples were used; the soil was allowed to dry and then passed through sieves of different degrees of fineness. The arthropoda thus collected were carefully classified. The researches lasted from October 1919 to May 1920; during this time viz., nine months, the soil fauna were more stable and numerous on the grassland than on the arable land, probably because grassland bears a vegetative covering, while little if any vegetation exists on arable land; further, the ploughing and working of the ground brings the fauna to the surface and exposes the animal life, not only to bird attack, but also to harsh climatic conditions, especially in the winter and early spring, thus disturbing many hibernating species. There was a corresponding increase in the fauna on all the three types of land as the vegetative growth increased. No characteristic fauna of arable land could be discovered; the predominant species were those commonly found on pasture.

The author has, however, not made any quantitative determinations, as these investigations are of a preliminary character. L. V.

501 - **Influence of Salts on Bacterial Activities of Soil.** — GREAVES, J. E. in *The Botanical Gazette*, vol. LXXIII, No. 3, pp. 161-180, bibliography of 29 works. Chicago, March 1922.

A study has been made of the influence of 24 salts on soil microflora and the minimum amount of solution required to effect certain forms of bacterial activity, such as ammonification, nitrification and nitrogen fixation. The results are tabulated clearly, showing the six cations of the different salts employed and the 4 anions and the measure of toxicity of the resulting 24 salts.

As regards ammonification, the maximum retarding effect was noted with potassium chloride and sulphate of iron (vol. mol. = 625×10^{-7}); then in order of sequence is placed calcium chloride and magnesium nitrate (156×10^{-7}) etc. The toxicity of a compound is regulated by both anion and cation; almost without exception the chlorides are more toxic than the corresponding nitrates. The sulphate varies according to the cation with which it is combined. The relative toxicity for the anions can be written as follows: $\text{Cl} > \text{NO}_3 > \text{SO}_4 > \text{CO}_3$; and the results for the cation: — $\text{Mn} > \text{Mg} > \text{Fe} > \text{Ca} > \text{Na} > \text{K}$ or the monovalent anion is more toxic than the bivalent and viceversa for the cation.

Results obtained with nitrification indicate that the nitrifying organisms are more sensitive than the preceding; toxicity of salt increases with concentration much more rapidly than in the case of the ammonifiers: — $\text{CO}_3 > \text{NO}_3 > \text{SO}_4 > \text{Cl}$; and of the cations $\text{K} > \text{Mg} > \text{Fe} > \text{Mn} > \text{Ca} > \text{Na}$.

As regards nitrogen fixation, the organisms concerned, are on the contrary very resistant, so that the concentrations employed were hardly ever strong enough to act as a retarding agent; the results do not therefore allow any definite conclusions to be drawn as to the degrees of toxicity of the various salts.

It appears, however, that toxicity is due in a large measure to osmo-

tic influences. Thus with 24 salts, 16 became toxic when the osmotic pressure ranged between 1.43 and 1.96 atmospheres. But other factors intervene; for example the range of toxicity for cations on ammonification organisms shows a similarity to that due to protoplasmic formation; it is very probable that the cations modify the proteins forming the protoplasm and in such a way as to incapacitate them for their normal functions.

All except 6 of these salts acted as stimulants of bacterial activity, measured by the quantity of ammonia, nitrates and nitrogen fixation.

In the investigations made on bacterial activity it was discovered that assimilation of part of the organic material occurs. This influence is well indicated in the solubility of the rock phosphate; to identify the changes due to bacteria, organic phosphorus has been treated with water soluble phosphorus. The results obtained show that certain salts, for example manganese carbonate, increased bacterial activity (135.1 % compared with the control), whilst with others such as magnesium carbonate a contrary effect was obtained (85.1 %).

L. V.

802 - Influence of *Azotobacter* added to the Soil on the Plant-growth -
FOUASSIER, M. and L'HOME, J., in *Comptes rendus des Séances de l'Académie d'Agriculture de France*, Vol. 8, No. 7, pp. 155-159. Paris, Feb. 15, 1922.

The writers recall that since 1877, SCHLOESING and MÜNTZ, on the basis of Pasteurian ideas, had shown that the processes of nitrification of nitrogenous matter are in correlation with the existence in the soil, of living agents, whose action is arrested by sterilising agents such as chloroform or heat. Later nitrification and the fixing of nitrogen were the object of researches on the part of BERTHELOT, JOULIE, A. GAUTIER, BRÉAL, ANDRÉ, etc. In 1893 WINOGRADSKY noted the symbiosis of Leguminosae with the nitrogen-fixing microbes; later he isolated one of the most active agents of this phenomenon, the *Azotobacter*; DÉHÉRAIN studied the action of *Azotobacter* on the soil in different conditions.

Meanwhile, methods were sought for favouring the multiplication of nitrogen-fixing microbes in the soil, for increasing their power, and for determining their solution by means of suitable sterilisation. LAPPARENT and RABATÉ observed that by spraying the soil with a $\frac{1}{10}$ solution of sulphuric acid to the extent of 1 cub. m per hectare an increased crop was obtained. In America and England sterilisation of the soil is practised in market gardening. In France TRUFFAUT and BEZSSONOFF after having studied the action of aromatic carbides fixed on calcium sulphide as sterilising agent.

The writers have made similar experiments; but for sterilisation they have used formol in doses of 3.45 per cub. m.; they abandoned the use of calcium sulphide because TRUFFAUT, who had recognised it as one of the best soil sterilisers, had also proved that the sulphur in its composition is a fertiliser. As nitrogen-fixing agent the writers used *Azotobacter agilis*, isolated to a pure state, and then cultivated in non sterilised, aqueous extract of earth, to which a little glucose was added: in this non-nitrogenous medium the *Azotobacter* soon got the upper hand while the other

plants perished. The experiments were made on 5 plots of ground in the open field, 1 sq. m. each and arranged in a similar way: one remained as control plot, two were sterilised, two not; in the case of each of these two pairs, to one plot was added mould containing 1.5 % of organic nitrogen; 4 hours after sterilisation broadcast sowing was made with clover seed; then over all the plots, except the control plot, the liquid containing the *Azotobacter* was poured using $\frac{1}{4}$ of a litre per sq. m., diluted with 5 litres of ordinary water. The differences in growth, at first imperceptible, became well marked towards the 20th day in favour of the *Azotobacter*; it is strange to record that the growth was greater in the sterilised plot to which no mould was added. Without wishing to exaggerate the importance of these researches, the inference is that *Azotobacter* is able to cause the fixation of nitrogen even if it is added directly to the soil. L. V.

53 - **Nitrogen Fixation in Ericaceae.** — RAYNER, M. C., in *The Botanical Gazette*, Vol. 73, No. 3, pp. 226-235, figs. 4. Chicago, March 1922.

The article gives a general review of the subject together with some new data.

It has been known since the middle of the nineteenth century that plants belonging to the Ericaceae form characteristic mycorrhiza, but it is only recently that some light has been thrown upon the relations between the plant-host and the endophyte.

In 1907 TERNETZ succeeded in isolating from the roots of certain Ericaceae several pycnidia-forming fungi which were all referred by LINDAU and HEMMINGS to the genus *Phoma*. They differed from the species previously found associated with Ericaceae in the small size of their pycnidiospores, and though isolated from plant species growing in close proximity, are specific strains, distinguishable by definite morphological and physiological characters. The most distinct forms were named *Phoma radicis Ericae*, *Ph. r. Tetralicis*, *Ph. r. Vaccini*, *Ph. r. Oxycocci*, *Ph. r. Anemodae* respectively. It should be noted that the isolation of fungi endophytic in the roots of plants is very difficult, and the identity of the fungi can only be proved by inoculation from pure culture into the roots of sterile seedlings and the consequent formation of the mycorrhiza typical of the species. TERNETZ's work in this connection is open to criticism, for he never succeeded in obtaining sterile Ericaceae seedlings, and hence there was no proof that the mycorrhizal condition was due to the inoculated fungi.

TERNETZ also tried to discover whether the *Phomae* he had isolated could fix atmospheric nitrogen. He therefore cultivated them in nitrogen-free media with all due precautions as to purity of materials, adequacy of controls and methods of estimation. The cultures were carried over a period of several years, and frequently repeated. It was found that none of the five strains investigated required a supply of combined nitrogen for healthy development or growth. They all fixed atmospheric nitrogen, but in very different degrees. From his own comparative experiments, which agreed in this respect with the results obtained by other investi-

gators, TERNETZ found that the strains of *Phoma* are much less energetic nitrogen fixers than *Azotobacter chroococcus*, *Clostridium pasteurianum* and *C. americanum*, but more economical as regards the amount of dextrose consumed to obtain the energy necessary for the process; for example the maximum amount of nitrogen combined for each mg. of dextrose used by them was 22 gm. as against 10.6 gm. in the case of the nitrogen-fixing bacteria. The values obtained for *Aspergillus* and *Penicillium* were too small to have any serious value.

In ignorance of the work of TERNETZ, the author made an exhaustive experimental study of an Ericacea, *Calluna vulgaris* and published the results in 1915. He showed that the fungus is already present in the testa of the seed and infects the young seedling immediately after germination. A pycnidia-bearing fungus was eventually isolated with comparative ease from unopened fruits. Proof of the identity of this fungus was provided by reinoculation into seedlings raised from sterilised seed. The author tried to detect the symbiotic relation between *Calluna* and the endophyte, and found that the former could not grow in a sterile medium thus proving that a remarkable case of *compulsory symbiosis* existed between the two organisms. The hyphomycete is distributed throughout the plant tissues of the host including the seed-coat and eventually reaches the ovary; the mycelium spreads to the seed-coat, so that the seedling become infected. Root-formation by the seedlings is dependent upon early infection by the endophyte: if this does not take place, development ceases and the young plant perishes. It is probable that the same conditions exist in the whole family of Ericaceae and in fact ovarian infection has been reported for many species, and the inability of seedling to complete their development without infection has already been proved in a number of cases.

Similar conditions are also to be found among the Orchidaceae, but here the endophyte is localised in the root-cells, so that the infection of the seedling is not insured. There is visible evidence in orchids of the digestion of the mycelium by the cells of the root, and it is clear that by this means the plant can draw indirectly upon organic compounds of carbon and nitrogen in the soil.

In the chlorophyllous orchids the endophyte can utilise the products of photosynthesis; otherwise the higher plant lives as a parasite at the expense of the fungus. This condition has been fully demonstrated for *Gastrodia elata*, a Japanese orchid, parasitic upon a fungus, *Armillaria mellea*. It is certain therefore that one at least of the so-called "saprophytic" orchids is to a certain extent parasitic. This is the more interesting because the fungus in its turn has parasitic habits and invades the tuber of the orchid in the first instance in exactly the same manner as it attacks the tubers of the potato; it is only afterwards that the fungus supplies the orchid with food. These facts explain the ecology of *Calluna*. There is no indication in this Ericacea of digestion of the *Phoma* mycelium by the root nor are there any obvious symptoms of attack or defence beyond the fact that the hyphae effect an entry and spread from cell to cell. It is

ly in the mesophyll cells of the leaf that the mycelium undergoes division. The mycelium in its turn draws its supply of organic compounds from its host; as is proved by the cultures in solutions of mineral salts and the power it possesses of hydrolising arbutin. This being so, the question of the use of the endophyte to the Ericaceae naturally presents itself. There is abundant evidence that the fungus can fix atmospheric nitrogen to a greater or less degree and supply it to the host in return for the organic compounds it obtains from the host. Of this fact the following proofs have been obtained: 1) infected *Calluna* seedlings, germinated on filter paper moistened with distilled water are vigorous and longlived; 2) the endophyte is widely distributed through the plant tissues, develops in the intercellular spaces of the leaves and emerges into the air from the surface of the shoot, as if to obtain nitrogen from the atmosphere; 3) the mycelium afterwards digested by the mesophyll cells in which the fixation of nitrogen takes place. On the other hand there is no evidence that the endophyte of Orchideae can absorb atmospheric nitrogen, for it does not spread into the chlorophyllous tissues.

In 1916, DUGGAR and DAVIS made an experimental survey of previous work on nitrogen fixation by fungi and extended the observations of earlier investigators, taking special precautions to avoid dubious experimental methods. They tried many species and varieties of fungus, among which was *Phoma Betulae* which has the power, common to all the *Phomae*, of fixing atmospheric nitrogen. In this manner an indirect proof of nitrogen fixation on the part of Ericaceae by means of endophytes was obtained.

The author has recently provided a further experimental proof. He has already grown two sets of *Calluna* seedlings, the one in agar-agar free from combined nitrogen, and the other in the same medium, but with the addition of a 0.5 % concentration of potassium nitrate as being the solution most suitable for the purpose. No special precautions were taken beyond the use of pure chemicals and freshly distilled water. The seedlings grew equally well in both cases, and those not supplied with nitrate were of a brighter green.

The experiments have since been repeated using every possible precaution to avoid contamination by traces of combined nitrogen. A similar solution of inorganic salts was made up in silica jelly prepared from specially purified materials and ammonia free water. The results obtained confirmed those already described, although owing possibly to mechanical difficulties offered by the silica jelly, the seedlings did not take root freely.

It may be objected that the seeds used their reserves of nitrogen, but when sterilised seeds were employed and no nitrates given, the seedlings turned yellow and the leaves became discoloured, these symptoms being relieved by inoculation with a pure culture of the endophyte. The fixation of nitrogen by Ericaceae through the medium of species of *Phoma* has thus been clearly demonstrated and with their aid Ericaceae can grow and thrive in soils deficient in nitrogen.

These researches have in part been carried out at the Pilcher Research Laboratory, Bedford College, University of London.

L. V.

- 804 - **The Micro-organisms of Sulphification** (1). — I. WAKSMAN, S. A. (New Jersey Agricultural Experiment Station, Department of Soil Chemistry and Bacteriology). Micro-organisms concerned in the Oxidation of Sulphur in the Soil, I. Introduction, *Journal of Bacteriology*, Vol. VII, No. 2, pp. 231-238, Baltimore, March 1922.
 II. WAKSMAN, S. A., and JOFFE, J. S. (Id.) Id., II. *Thiobacillus thiooxidans*, a New Sulphur Oxidising Organism isolated from the Soil, *Ibid.* pp. 239-236, figs. 2
 1 pl., bibliography of 36 works.

The micro-organisms of sulphification have been very carefully studied by OMELIANSKY, DÜGGELLI, and KRUSE. The author takes up the subject with the object of establishing the present state of knowledge of the question and of using the data collected as a starting point for further investigation.

Hydrogen sulphide, sulphides and thiosulphates undergo a spontaneous oxidation process resulting in the separation of sulphur. The sulphur thus produced, like natural sulphur, if finely subdivided, is further oxidised with the production of sulphuric acid; the latter, reacting with carbonates and other salts, forms sulphates.

The process takes place very slowly as a result of the action of simple physical and chemical forces, but is greatly accelerated by specific bacteria; this was pointed out for the first time by WINOGRADSKY who referred to them under the name of *sulphur-bacteria*. In the transformation which sulphur and its compounds undergo, two types of bacteria are concerned, the one being a reducing, the other an oxidising agent. The sulphur-bacteria belong to the second class and are very energetic in their action. The first sulphur-bacteria studied by WINOGRADSKY contained granules of sulphur resulting from the oxidation of the hydrogen sulphide dissolved in the medium; subsequently, many other micro-organisms were found to possess the power of oxidising hydrogen sulphide, sulphides, thiosulphates and sulphur, some of them being able to accumulate sulphur in their cells. These microorganisms are very heterogeneous in character.

In nearly all the work which deals with the oxidation of sulphur by bacteria the point of departure of the process was not regarded as sulphur but as hydrogen sulphide, sulphides and thiosulphates; the oxidising power of these bacteria not being estimated by the oxidation of the sulphur and hence by the production of sulphuric acid and sulphate or the change in the reaction of the medium, but only by the appearance and disappearance of the granules of sulphur. This was due to the fact that the sulphur bacteria were studied in sulphur springs, mud baths, sea-water, drinking water and drainage-water, very little attention being paid to the micro-organisms that oxidise the sulphur of the soil. It was only later that these micro-organisms aroused interest, as a result of the researches of JACOBSEN and other writers. It has also been recognised that the oxidation process takes place in two stages; the sulphur is produced first and afterward transformed into sulphuric acid. Two large classes of micro-organisms are

(1) See R. 1919, No. 693. (Ed.)

pecially concerned in the work. The bacteria of one class oxidise the hydrogen sulphide, sulphides and thiosulphates removing the sulphur which they accumulate internally and subsequently oxidise. These bacteria cannot oxidise external sulphur, and are therefore of little importance regards the chemical changes which take place in the soil; they have, however, been more completely studied than the bacteria of the second class. These are either unable to bring about the preliminary changes, or can only carry them out unsatisfactorily; they alone, however are, capable of oxidising external sulphur. These bacteria are the more important for agriculture, but scientific knowledge of them is still incomplete.

Each of the two large classes can be further subdivided into smaller groups according to their morphological characters and physiological properties. The micro-organisms capable of storing up sulphur in their protoplasm consist of 3 groups: 1) colourless and filamentous; 2) colourless and non-filamentous; 3) purple rhodobacteria. The micro-organisms that cannot accumulate sulphur within themselves, but are able to oxidise external sulphur, can be divided into 2 groups according as: 1) they themselves deposit the sulphur externally and separate it from the other compounds; 2) they do not deposit sulphur. The latter group is the more active. There are thus 5 groups of sulphur-bacteria each of which can be studied separately.

1st GROUP. — This is the best-known, for it has been the longest investigated. It includes three genera; *Beggiatoa*, mobile forms of bacteria; *Thiothrix*, immobile forms of bacteria (both of these have no sheath), and *Thioploea* composed of bacteria covered with a gelatinous sheath. The *Beggiatoa* are the classic sulphur-bacteria. As long ago as 1870, CRAMER recognised that the granules they contained were sulphur; later, COHN was of opinion that the *Beggiatoa* and the purple bacteria reduced the sulphur they contained and produced hydrogen sulphide. WINOGRADSKY subsequently showed that exactly the opposite process takes place, the sulphur accumulated in the protoplasm of these bacteria which is present in the form of soft globules incapable of crystallisation is the product of the oxidation of hydrogen sulphide; when subsequently oxidised, it produces sulphuric acid, which is neutralised by the carbonates and bicarbonates, and liberates carbon dioxide; hence the medium never becomes acid. These processes are exothermic, that is to say they entail a certain production of heat, thus supplying the bacteria with the energy they require for living and building up their organic substance. If these micro-organisms are deprived of hydrogen sulphide, they burn up all their accumulated sulphur and then perish. Traces of nitrates or of other simple nitrogenous substances are all they need for the construction of their plastic materials, but peptone, sugar, etc. which promote the growth of other bacteria are useless or injurious to *Beggiatoa*. KEIL believes himself to have obtained pure cultures of *Beggiatoa* and *Thiothrix*. He clearly recognised that both species can live in media containing no organic matter, for which reason he called them autotrophic. KEIL showed that these bacteria can obtain from carbon dioxide all the carbon they require for

the formation of organic matter, and he states that the presence of carbonates is necessary for the neutralisation of the sulphuric acid. The different species of *Thioploea* have been studied by WISLOCK and by KOLKSWITZ.

2nd GROUP. — This is very heterogeneous and artificial. It contains most dissimilar forms, bacilli like *Thiobacterium* α and *Thiobacterium* β , described by JEGUNOW; spirilli like *Spirillum agilisimum* and *Microspira vacillans* described by GICKLEHORN, and even flagellates like the *Monas Mülleri* of HINZE.

3rd GROUP. — The rhodobacteria are characterised by two pigments distributed irregularly throughout their protoplasm: bacterio-purpurin, which is red, violet-red, or brownish red, and bacterio-chlorine which is green. Although these micro-organisms occur in large numbers in the water of sulphur springs and in mud impregnated with sulphur, they are unable to isolate the sulphur present. MOLISCH succeeded in obtaining pure cultures of some of these forms, but they were not sulphur bacteria. According to MADSEN and MOLISCH, sulphuric acid is not necessary to keep them alive, and they contain no sulphur granules; this statement, however, does not agree with the preceding observations made by WINOGRADSKY and others. The behaviour of these bacteria as regards sulphur is therefore an open question.

4th GROUP. — The bacteria composing this group were observed for the first time in sea-water by NATHANSON and subsequently found in drainage water, and in the soil. They oxidise hydrogen sulphide, sulphides and thiosulphates and accumulate sulphur externally forming a thick surface film containing sulphur which they can ultimately break through. The bacteria of this group are also able to use the carbon of carbon dioxide for the manufacture of organic matter. NATHANSON has cultivated them in liquid media containing, amongst other substances, thiosulphates and carbonates; BEIJERINCK has generally confirmed these results, and recognised that no other source of carbon is capable of replacing carbon dioxide. He isolated a very mobile, non spore-forming type of *Thiobacillus thioparum* and a very similar form of *Bacillus denitrificans*, capable also of liberating the nitrogen of nitrates. JACOBSEN has carried out some quantitative experiments to determine how far *Thiobacillus* is able to oxidise external sulphur. LIESKE and GOEHRING have found *Bact. denitrificans* in many soils, while GICKLEHORN has met with bacteria of the same group in garden mould, but has never isolated them.

5th GROUP. — Although the first four groups are well-known and have been described in microbiological treatises and in special studies on sulphur-bacteria, little attention has been paid to this last group, although it includes some of the bacteria that are most active in oxidising the sulphur of the soil. These are very common in soils to which crude sulphur has been added, and they obtain from it large quantities of sulphuric acid. The bacteria of the 5th group also oxidise thiosulphates to a slight extent, but cannot break up hydrogen sulphide or sulphides, and do not liberate sulphur; they form no surface film on the liquid on which they are growing, but are distributed equally throughout the mass; they extract all the car-

on from carbon dioxide. These micro-organisms, though excessively minute, are the most active sulphur oxidising agents and acid producers known. The group has but one representative *Thiobacillus thioxydans*, which is very common in the soil, and has been the object of preliminary studies on the part of the author in collaboration with JOFFE and LIPMAN.

II. — In a mixture of soil, mineral phosphate and sulphur, the sulphur is quickly oxidised into sulphuric acid, which converts the basic phosphate into neutral phosphate, then into acid phosphate and finally, when the phosphate supply is exhausted, it accumulates it on its own account unaltered. These facts were discovered by MACLEAN in 1918.

The authors have succeeded in isolating from the mixture a micro-organism which oxidises sulphur. They employed the dilution method, adding to the substance sterilised water in the proportion of 1 : 10 up to 1 : 10 000 000; and then added 1 cc. of the liquids thus obtained to 100 cc. of the cultural medium. This consisted of a suspension-solution in distilled water, of sulphur (1 %), basic phosphate of lime, ammonium sulphate and other mineral salts. The authors also tried adding glucose, but had to abandon it, as this carbohydrate encouraged the growth of moulds. By means of successive transplanting the cultures became gradually purified, as was ascertained under the microscope, and proved by the sterility of cultures grown in ordinary nutritive media.

The micro-organism isolated is a very minute bacterium with rounded extremities, gram positive, and non-spore producing; most of the individuals measure 10.5 μ . In its morphological characters it much resembles the two species of *Thiobacillus* identified by BEIJERINCK. For this reason, the authors have included it in the same genus under the name of *Thiobacillus thioxydans* n. sp.; it is however very different in its physiological behaviour, and has therefore been placed in a separate group. Unlike the two forms separated by BEIJERINCK, which liberate sulphur from hydrogen sulphide, sulphides and thiosulphates and deposit it externally, the new bacillus only attacks thiosulphates, and does not deposit sulphur, but oxidises the surrounding sulphur.

From sulphur, *Thiobacillus thioxydans* obtains all its life-energy. Its activity can be accurately gauged from the amount of sulphur oxidised; the quantity of sulphuric acid thus produced, or the amount of basic calcium phosphate dissolved by this sulphuric acid. Impure cultures have proved to be more active; they have oxidised as much as 20-30 % of the sulphur. The original acidity of the cultural medium was $\text{pH} = 5.6-6.2$; during the growth of the culture, it continually increased up to 2.8-2.6 where it remained stationary (this being the optimum growth acidity), until all the tricalcium phosphate had been dissolved by the sulphuric acid and transformed into tricalcium phosphate, monocalcium phosphate and phosphoric acid, the calcium being however precipitated in the form of the sulphate. The further oxidation of the sulphur resulted later in the production of free sulphuric acid which increased the acidity, the latter reaching values of pH ranging from 1 — 0.8 — 0.6. This high acidity hindered the further development of the culture, producing an auto-regulation of the acid content. If

much tricalcic phosphate was present, a larger amount of sulphur was oxidised, because the acid produced could be neutralised during a longer period without impeding the growth of the culture. An excess of tricalcic phosphate (as well as of carbonates), was not, however, easily tolerated.

The micro-organism obtains all its carbon from the carbon dioxide of the atmosphere. It has no need of carbonic acid obtained from carbonates by the action of sulphuric acid; carbonates never increased its growth and sometimes they were even found to hinder it, as occurred when the medium was rendered alkaline. The reason is that sulphur-oxidising bacteria prefer an acid medium, whereas nitrifying bacteria flourish in an alkaline medium. Bi-carbonate of sodium is not only useful to the nitrifying micro-organisms as affording a supply of carbon, but also and chiefly, because it renders the medium alkaline (MEYERHOF). For the same reason it may have an injurious effect on sulphur-oxidising bacteria. The latter are not tolerant of calcium oxide, for it has the power of producing too sudden a change in the reaction of the medium, whereas tricalcic phosphate is very useful in neutralising the sulphuric acid formed, owing to its insolubility and the acid compounds and insoluble deposit to which it gives rise.

The best source of nitrogen proved to be the inorganic salts of ammonium, but other compounds can also be used.

In conclusion, *Thiobacillus thioxydans* (which is doubtless the first recognised individual of a group of energetic sulphur-oxidising bacteria), is distinctly autotrophic, that is to say able to live and grow at the expense of organic matter alone; it derives its energy from sulphur, the carbon present in carbon dioxide, and the nitrogen of mineral salts. Glucose is not injurious to the bacterium, but has no effect upon the production of sulphuric acid. Autotrophic microorganisms possessing the power of manufacturing organic matter from mineral substances in the same manner as higher plants, but without the aid of sunlight, or chlorophyll are not only of considerable agricultural importance, but also of great general biological interest, as probably being the earliest representatives of organic life upon the globe.

L. V.

*5 - Researches on the Efficacy of Deep Tillage and on the Distribution of the Roots of Certain Plants in Different Strata of Soil. — AVANZI, E. (Istituto agrario della R. Università di Pisa), in *L'Agricoltura Italiana*. Year XLV, parts 1-3, pp. 41-56. Pisa, 1922.

Preliminary researches commenced in May 1920, with the object of determining the influence which the depth of preparatory tillage might have on different crops grown in succession on the same soil. In a preliminary experiment frames 10 cm. in height were placed one on top of another and sunk on garden soil normally dug with the spade; each series of 5 frames was filled with soil which had been dug over and exposed to the sun. An analysis of the soil was made and the fundamental manuring consisted of mineral superphosphate and nitrate of soda; buckwheat and millet were sown in two series, succeeded by autumn wheat and white

mustard; the second season was particularly dry, for which reason the humidity of the different boxes and the different strata of soil was determined at the end of the experiment.

It is easily understood, after what has just been stated, that the results of the researches made cannot be applied in practical cultivation. However, these researches allow certain conclusions to be drawn which confirm the general rules regarding the influence of the depth of tillage in regard to different crops.

If the produce obtained with the various plants used in the experiment is examined, it is noticed that the increased production due to greater depth of tillage was realised, as is easily supposed, with the crops which were formed immediately after the execution of the tillage. It is next noted that the increased production has not taken place in proportion to the depth of the tillage, since this increase after reaching its maximum for the first deepening of the tillage (from 10 to 20 cm.), has then become less accentuated; and, after having attained a maximum, instead of continuing to grow in proportion to the depth, has, on the contrary, decreased in a sudden and marked manner; and it has done so very probably owing to the intervention of injurious actions exercised by the mineral and organic matter situated in the deep strata and brought to the superficial strata. It is further remarked that the favourable effect of deep tillage was particularly manifest with millet, which, on account of its great vegetative activity and its rapidity of growth, consumed a greater quantity of fertilising substances and water for the production of a much greater quantity of organic matter than that produced by the buckwheat. The crop of wheat which followed that of millet and buckwheat also felt the effects of the different depth of tillage previously done, but the effect in its case was much less; to such an extent that if there was a noticeable increase in the production of grain there was often a reduced production of straw.

Another fact which this crop has brought into prominence concerns the slightly smaller quantity of grain obtained from the wheat which followed the millet compared with that yielded by the wheat which followed the buckwheat. The white mustard, having gone through a period of scarce rainfall, felt the effects of the tillage also in a notable manner, and its increased production was similar to those recorded for the former crops.

A final remark concerns the smaller amount of humidity in the upper layer of soil where the tillage was only 10 cm., in comparison with the humidity contained in the soil of the corresponding layers where the soil had been more deeply turned up; and this will seem all the more remarkable if it is remembered that in the former case there was also a smaller consumption of water, owing to the smaller amount of organic matter produced.

Other researches on the distribution of the roots of certain crops in the different layers of soil accompanied the former; they were made with rules and methods similar to those above mentioned, with this difference

that the frames were 15 cm. high. In five parallelepipeds of soil formed of five frames superimposed, indigenous selected maize, millet, hemp, giant sunflower, and Kentucky tobacco in transplants were sown on the 25th May 1920. The vegetative phases passed regularly and, in October when each species had finished its vegetative cycle, the roots were examined.

The writer concludes from that examination that the greater part of the root-system of the species considered was found in the most superficial part of the soil, to the extent that about 90 % of the weight of the roots are in the first 23 cm. of depth. However, it should not be forgotten that a good part of the weight of the roots found in the upper layers is constituted the taproots or by the thickest roots while the deeper layers only contain the capillary roots.

As is easily supposed each plant is distinguished by a characteristic root system. Maize has strong principal roots to which are attached numerous capillary roots, very largely found in the first and second layers.

Millet has a root-system very similar to maize ; but it is much more abundant and formed of more resistant and more pliable roots.

Hemp has a root-system which may be considered as typical of plants with tap-roots : from the taproots start more or less stout secondary roots to which are attached the system of capillary roots formed of very fine rootlets. The sunflower is indicated, as is well known, as a taprooted plant : it has, it is true, a very strong taproot which buries itself beyond the third layer ; but, differing from true taproots, it has a capillary system of very fine rootlets which spreads out mainly in the more superficial layer.

Tobacco, owing to transplantation, has not a true taproot, since at a depth of a few centimetres (4 to 6) the taproot is replaced by very strong secondary roots spreading chiefly in the lower layers and bearing capillary rootlets which reach a considerable depth.

The form and distribution of the root-system may serve to justify the various exigencies of plants in the matter of soil, preparation, tillage, manuring and cultural care. In any case, we should never neglect the direct or indirect influences which tillage exercises on the physical, chemical, and biological properties of the soil and which are expressed by greater or less vegetative activity of the plants cultivated.

Another fact, which we must beware of neglecting in the matter of tillage and manuring concerns the rate of growth of the root-system ; it probably is very different in various plants. In fact, the above-mentioned researches have given prominence only to the final conditions, but it would not be without importance, especially in connection with the application of quick acting manure, to follow the development of the root-system of different species of plants in their most typical vegetative phases.

G. A. B.

806 - Application of Electricity to Cultivation. — See Nos. 814 and 867 of this *Review*.

805-806]

807 - **The Effect of Gypsum on Soil Reaction.** — ERDMAN, L. W. (Iowa Agricultural Station) in *Soil Science*, Vol. 12, No. 6, pp. 433-448, bibliography of 32 publications. Baltimore, Dec. 1921.

Gypsum has been used as a fertiliser for many years and has often proved to be valuable when applied to small grains and clovers.

The early investigators claimed that gypsum increased crop yields for a time, but its continued use failed to maintain those increases, and, as it contained no nitrogen, phosphorus or potassium, it was regarded as a soil stimulant. Recent investigations have shewn that the value of gypsum is probably due to its sulphur content, as many soils have been found to be deficient in this essential plant-food element, which is more important in the case of certain crops than was formerly supposed. As gypsum supplies sulphur in a form available to plants it may play an important part in the fertility of soils which are deficient in this element. It is believed also that gypsum has an indirect action in modifying other soil constituents. Gypsum cannot replace lime as a means of correcting soil acidity, but opinions differ as to whether or not when applied to soils it tends to make them acid. Gypsum is a neutral salt and on dissociation ought to give rise to hydrogen and hydroxyl-ions of equal concentration, which might modify soil acidity; at the same time there may be secondary reactions, which theoretically may cause a certain amount of acidity.

The author decided to test as far as possible the effect of gypsum on soil reactions.

The literature on the subject contains references to experiments dealing with gypsum itself, and also with superphosphate which contains about 60 % of gypsum, consequently the effect of the fertiliser may be partly due to this substance. The work of GARDNER and BROWN in 1910 on plots which had received gypsum at the rate of 320 lb. per acre every two years for a period of 30 years, showed that these plots were slightly more acid than those which had received none, but the difference was so little that FREAR concluded that gypsum did not add to soil acidity.

SCHOLLENBERGER found that gypsum applied to manure decreased acidity; CONNOR obtained similar results; on the contrary, LIPMAN stated that it did not correct acidity; SKINNER and BEATTIE maintained that it added to acidity; SINGH the same. VEITCH and CONNOR applied superphosphate and found acidity decrease: BROOKS, PLUMMER AMES and SCHOLLENBERGER found no appreciable difference. These experiments were carried out by various methods.

The author used TACKE's method, as slightly modified by STEPHENSON: it consisted of treating the soil with an excess of calcium carbonate and estimating the volume of carbon dioxide evolved.

The results were checked by the method of MACINTYRE and WILLIS, based on the determination of the residual carbonate; a direct evaluation was also made of the hydrogen-ion concentration.

To summarise the results, it may be concluded that gypsum applied in amounts up to and including 500 lb. per acre does not increase or decrease the soil-reaction as determined by the TACKE-STEPHENSON meth-

od. An application of 1000 to 2000 lb. per acre causes a slight increase in hydrogen-ions in an acid or neutral soil, but very little in the case of a basic soil.

Gypsum added at the rate of 500 lb. per acre to a neutral soil made to vary in degrees of acidity by additions of HCl and Ca CO₃ had no effect on the hydrogen ion concentration of the soil, and did not show sufficient lime requirement by the STEPHENSON-TACKE method to justify the conclusion that gypsum had any effect on soil acidity. L. V.

808 - **Herbaceous Growth of Arborescent Plants for the Production of Manure and Forage in Cuba.** — CALVINO, M., in *Boletín N. 47, Secretaría de Agricultura, Comercio y Trabajo, Estación Experimental Agronómica*, 16 pp., fig. 6 Habana, 1922.

By sowing very thickly the "gelso bianco" (*Morus alba*) or still better *M. multicaulis* and cutting it level with the ground several times a year, a sort of meadow is obtained which can be mown with the same apparatus and machines as herbaceous plants (1).

The writer proposes the adoption of this method for the growth of two arborescent leguminous species of tropical regions introduced into Cuba: — *Cassia siamea* Lamk. (*C. florida* Vahl.) and *Albizia Lebeck* Benth. The former called "Cassia del Siam" in Cuba, "Kassod tree" in the Hawai islands and "wa" in India, is a native of Southern India, Burma, Ceylon and of the Malay peninsula and Siam. Grown in its natural form it furnishes a good firewood and cabinet wood, grown as a hedge it serves as a wind screen; if sown thickly and cut often it gives a large quantity of herbaceous material rich in nitrogen and suitable for use as green manure.

In the experiments made by the writer at the Havana Experimental Station with seed obtained from the Philippines, by sowing on the 7th May 1920, transplanting at a spacing of 60 cm. x 60 cm. on the 2nd June of the same year and cutting for the first time on the 8th July 1921, the second on the 17th November 1921 and the third on the 31st March 1922, he obtained respectively, without any irrigation, 1212 — 572 — 320 qx. per hectare of tender leafy branches, easily decomposed, each 1000 kilogrammes made up of 498 kg. of leaves and 502 kg. of branches.

The leafy branches at the time of cutting contain in their leaves 52.4 % of moisture, 44.33 % of organic matter and 3.27 % of mineral matter and in the branches respectively 49.85 — 48.64 — 1.51 %. They contain nitrogen in the proportion of 1.88 % in the leaves and 1.3 % in the branches. By drying at 30°, the moisture is reduced to 9.7 % in the leaves and to 7 % in the stems; the nitrogen becomes respectively 3.57 % and 2.40 %. The ash of the leaves contains: — 27.05 % of lime; 12.8 % of potash; 6.12 % of phosphoric acid; the ash of the branches contains respectively 8.78 — 10.63 — 5.05 %. For the purpose of comparison, the writer recalls that the "cowpea" (*Vigna Catjang*) contains in the fresh leaves 0.33 % of nitrogen, the "velvet bean" (*Stylobium* spp.)

(1) See: R. FORLANI, *Il prato gelso*. Catane, Battiato, 1920. (Ed.)

0.37 % and the "fandul" (*Cajanus indicus*) 1.12 %, that is to say they are all inferior to *Cassia siamea*.

As 1000 parts by weight of fresh leafy branches contain 15.88 of nitrogen, 2.89 of potash, 1.134 of phosphoric acid and 5.03 of lime, if 50 tons of these branches are applied to 1 hectare of land, as green manure, it is furnished with 794 kg of nitrogen + 114.5 kg. of potash + 67 kg. of lime. *Cassia siamea* is not eaten by animals; it is not subject to diseases, nor attacked by insect pests.

For use as transported green manure the writer recommends as follows:— before spreading and burying the cut branches, let them steep in water in which farmyard manure in fermentation has been soaked (as is done in India) and to which has also been added 2 % of phosphate of ammonia or 1 % of superphosphate and 1 % of sulphate of ammonia; much more rapid decomposition is thus obtained. One of the systems suggested in England for the production of artificial manure (1) may also be adopted, that is to say mixing the plant with ground limestone and sulphate of ammonia or simply with cyanamide of calcium and let it ferment by watering from time to time. The writer recommends mixing 100-160 kg. of cyanamide of calcium and an equal quantity of Cuban bats phospho-guano with 2000 kg. of leafy branches.

Albizzia Lebbeck, called "algarrobo de olor" in Cuba, "blackwood" in French Colonies and "women's tong tree" in British Antilles, may be used with the same object. This plant is a native of tropical Asia where it is much used as shade trees for coffee. Compared with *Cassia*, *Albizzia* has one disadvantage, it drops its leaves in the middle of the dry season, in spring; but if it is sown very thickly and cut very low it remains always in leaf. It is moreover well liked by cattle and can therefore also be used as forage; its leaves contain 1.19 % of nitrogen and are rich in mineral constituents. As is the case with the "Cassia del Siam", it shoots again rapidly after cutting and grows quickly. Previously the writer had recommended, as a plant for green manure in Mexico, the herbaceous growth of "mezquite" (*Prosopis juliflora*) which is spontaneous in the barren and semi-sterile soils of the "Mesa central".

809 - **Sweet Clover as a Green Manure.** — WHITING, A. L., and RICHMOND, T. E. in *University of Illinois Agricultural Experiment Station, Bulletin No. 233*, pp. 255-267. Urbana, May 1921.

Sweet clover (*Melilotus alba*) should prove a promising source for supplying nitrogen to the chief farm crops. Certain characteristics give it a marked superiority over other crops as a green manure. The most important of these are:

Adaptability to a wide range of climatic and soil conditions, if the soil is not acid and inoculation is assured; hardiness to cold and drought, resistance to disease and damage from weeds; vigorous growth; rapid decomposition whilst green; deep-rooting habit which renders impervious sub-soils more porous and of higher nutritive value.

(1) See R. March. 1922, Nos. 236 and 237. (Ed.)

A crop that possesses the combined capacity to grow rapidly in early spring and to decompose readily, makes an ideal green manure. Owing to its rapid growth clover conserves large amounts of soluble plant food, utilisable when the soil would otherwise suffer heavy losses. Similar to other legumes, when properly inoculated, the plant can utilise atmospheric nitrogen which it stores in its roots as reserve food material. The leaves are very tender and decay immediately after the crop is turned under green. The roots and stems decay more slowly; thus the different parts represent three sources of nitrogen which furnish three rates of nitrate production.

Hitherto considered as a weed, the sweet clover is now coming to be regarded as the best crop for soil improvement. As it will supply nitrogen at a low cost, it could be employed on a large scale.

The literature concerning sweet clover as a green manure and as a source of nitrogen is very limited. Having been classed for some time as a weed, it has received very little attention by investigators. ORTH in 1890 was the first to test the value of this crop as a green manure and proved its superiority over farmyard manure for the production of potatoes, oats and maize. G. B. HOPKINS recognised the possibilities of this plant as a green manure and in his book on "Soil Fertility and Permanent Agriculture", he states that 6 $\frac{1}{2}$ tons of dry matter furnish as much humus and nitrogen as would be furnished by 25 tons of average farmyard manure. The appreciation of the importance of this crop is evident in that he introduced it into the rotations on several experiment stations and also selected sweet clover as the crop upon which to base his foundation work for restoration of the soils of Greece. In 1917, MAYNARD studied the decomposition for nitrate formation under glass and found it to be very rapid. He mentions that no record has been found of any study of the rate of decay of sweet clover as a green manure.

The work of MERTZ deserves attention, especially designed to compare the value of various green manures, leguminous and non-leguminous, the latter being reinforced with artificial nitrogenous fertilisers. The experiment was conducted in South California. The crops grown for green manures in the winter were followed by maize, potatoes, cabbage, beets, sorghum and Sudan hay, for six successive years. The legumes proved much superior to the non-legumes and amongst the former the bitter clover (*Melilotus indica*) an annual variety of sweet clover was the most promising, both from the standpoint of vigour, of seed supplies and as a green manure. The use of *M. indica* resulted in a gain of nearly 20 bus. of shelled maize per acre. This compares favourably with results obtained with an annual application of sodium nitrate giving 1080 lb. per acre of maize and of dried blood giving 1200 lb., taking into account also the cost of these fertilisers.

The advantage of utilising the crop as a manure has been proved by the authors in their experiments made (1918-19) on 5 specially selected fields in northern, central and southern Illinois, in connection with the University Farm, Urbana. A series of plots was arranged as follows:

sweet clover; green manure; control; to the sweet clover and manured plots, rock phosphate or bone meal was added once in four years. On the sweet clover green manure plots, residues were added to compensate for corn stubble. A distinction should be drawn between available and non-available nitrogen as it is most important to keep as much nitrogen as possible in the available form. This is exactly what happens in the case of leguminous crops, which help to contribute large quantities of available nitrogen. The results obtained by the authors indicate that after digging in, the sweet clover tends to increase the proportion of nitrates in the soil, even more than heavy applications of manure. In poor soils the effect is even more marked. The maximum nitrate production was noticed in August which suggests the advisability of ploughing under at an earlier date, and so avoiding any detrimental effect (due to decomposition) on the germinating maize. Another suggestion is the utilisation of the surplus nitrate by sowing a catch crop. When maize is the main crop, the value of the additional nitrate remains although quickly utilised by the crop. Even when manure, lime and phosphate have been used in large quantities (5 times normal application), the yields were not equal to those obtained after sweet clover.

The average for the 2nd year sweet clover crop was 87.6 lb. nitrogen per ton of dry matter, the cutting was made before sowing the maize. The subsequent advantage was evident.

These results furnish positive information concerning the value of sweet clover when used as a green manure, for adding to, conserving and making available for crop purposes the nitrogen of the soil. It is well-known that, except for manure, the animal sources of nitrogen (dried blood, tanning residue, guano etc.) are scarce and costly and therefore unsuitable for use on a large scale. This applies also to the use of nitrogenous fertilisers (sodium nitrate, sulphate of ammonia, ammonium phosphate and calcium cyanamide). On the other hand, the leguminous crops offer an exceptional advantage, and sweet clover in particular may in the future occupy a prominent position as a green manure.

L. V.

810 - **The Nitrogenous Compounds in Lucerne Hay.** -- MILLER, H. C. (Chemical Division of the Oregon Experiment Station), in *The Journal of the American Chemical Society*, Vol. 43, No. 12, pp. 2656-2663. Easton, Pa., December 1921.

The author has succeeded in isolating from lucerne hay certain non-protein nitrogenous compounds containing 40.7 % of nitrogen; most of them can be easily extracted with water. Purins make up 3.2 % of the total nitrogen. The author has determined the percentages of the different constituents of the protein compounds, and in particular of the amino-acids: arginin, hystidin, lysin, cystin, etc. He finds that they contain 13 % of nitrogen, whereas the amount of this substance present in the proteins of lucerne seed is as much as 15.6 %, owing to the different percentages of the various constituents, and especially, to the larger quantity of arginin which is very rich in nitrogen. The author describes a new method for the further study of the non-protein substances. This consists

in the precipitation of the aqueous solution by chloride of mercury and the subsequent removal of the mercury.

L. V.

811 - **The Chemical Composition of Plants as a Basis for the Estimation of their Water Requirements.** — NOYES, H. A. (Mellon Institute of Industrial Research, Pittsburgh, Pennsylvania), in *The Journal of Industrial and Engineering Chemistry*, Vol. XV, No. 3, pp. 227-228. Washington, March 1, 1922.

The author refers to the results of field and greenhouse experiments carried out at the Agricultural Station of Purdue, La Fayette U. S., which prove that the direct, or indirect, manuring of the soil causes a decrease in the water requirements of growing plants and also changes their composition. Working the land has the same effect, for the soil is thereby more exposed to the air which increases the bacterial activity and this, in its turn, brings about the greater concentration of the soil solution.

By the application of a suitable fertiliser and the timely working of the land all danger from drought could be greatly reduced in the case of crops growing in the wet zones of the United States, for by these means the plants are enabled to enter upon the dry season with an accumulated store of moisture. The manuring of the soil will therefore have to be studied from another point of view viz., the water requirements of the crop.

The author is of opinion that the old advice given to farmers, "work the soil well so as to retain its moisture and the best crops will obtained", might be modified as follows: cultivate the land thoroughly so that the soil may be well ventilated, because air increases bacterial activity and enables the plants to obtain a larger amount of nutritive substances and to grow with less moisture.

The following data confirm this statement. In the course of his field and orchard experiments made at the Agricultural Experiment Station of Nebraska, KRISSELBACH obtained the results given in the appended Table.

	Cleaned land cover crops	Land dressed with straw	Land untilled for several years
Increased girth of trees from 1911-1916 in cm.	25.5	25.9	17.1
Nitric nitrogen in the soil during the vegetative season per thousand parts of dry soil.	57.5	47.0	14.5
Water at beginning of vegetative season, kg. in 30.5 cm. × 30.5 cm. × 22.9 cm. .	5.12	5.24	5.37
Water at end of vegetative season <i>idem</i> . .	3.83	5.10	3.66

Greenhouse experiments on *Capsicum annuum* var. *abbreviatum* and lettuce have shown that by the application of dung and of a complete chemical fertiliser the water units required to produce one unit of green

stances are reduced by more than a half, while the plants themselves are times as heavy as the controls. Further, the water requirements estimated by the water content of plants treated in different ways (controls, manured, manured with phosphatic, and nitrogenous fertilisers, dung, or complete fertiliser), as well as their nitrogen content (green portions and roots), and the amount of phosphorus and calcium present in their ash all show the existence of a correlation between the composition of plants and their need of water. G. A. B.

2 - **Influence of Conditions of Humidity on the Growth of Sainfoin Seeds respectively Unhusked and Husked.** — RIVERA, V. (R. Stazione di Patologia vegetale, Roma) in *Rivista di Biologia*, Vol. 4, No. 1, pp. 1-12. Rome, 1922.

In the working of meadows of sainfoin (*Onobrychis sativa* All.), the results obtained are very variable, which has led the writer to study closely the growth of the seed of this leguminous plant under the experimental conditions of the laboratory.

For each experiment a portion of the seeds were husked and the others left in their pods. In a first series, the seeds were placed in various conditions of humidity by forming 4 groups in Petri capsules:— (1) capsules containing water in which the seeds were kept immersed by means of a glass; (2) capsules containing blotting paper abundantly soaked in water; (3) capsules containing blotting paper soaked to a limited extent; (4) capsules in which a humid atmosphere was produced by moistened blotting paper placed inside the cover. The first two groups of seeds behaved in an identical manner; they are therefore considered together; in them the absorption of moisture was very rapid: after 42 hours the maximum was reached, and their weight was almost doubled; on the other hand it required 90 hours for the seeds placed on the paper slightly moistened to absorb about half their weight of water and those placed in a humid atmosphere absorbed about one third.

It is interesting to note that the seeds on slightly moistened blotting paper germinated first; it is clear that in the other cases the seeds found themselves in conditions less suitable for their growth owing to excess or deficiency of moisture: the delay has a distinct biological significance, but it is evident that excessive conditions of moisture cannot be prolonged beyond a certain limit.

Regarding the different behaviour of unhusked and husked seeds, one of the effects of the presence of the pod is a delay of a few days in the beginning of germination; this delay may be caused by the fact that the soaking of the seed is retarded, since the pod first imbibes the water and the seed afterwards; it may also be attributed to the pressure which the pod exerts on the swollen seed.

The amount of water absorbed by the pod is maintained in the same proportion as that absorbed by the seed: in fact, the difference between the percentages of water absorbed by the unhusked and husked seeds are negligible, especially after 90 hours. The pod therefore stores much moisture and can restore it later; by its structure, which makes it like a

sponge, it creates an ideal humid chamber for the seeds which it contains. The power of disposal of moisture is therefore, superior in the unhusked seeds than in the naked seeds.

If the seeds are next placed in a dry medium, those which are unhusked lose less moisture than the naked seeds. The writer assured himself of this in a second series of experiments in which he exposed seeds swollen with moisture, to a drying action, obtained by means of chloride of lime. For example, in one of his experiments, after two days drying the unhusked seeds still contained 0.32 gm. of moisture and the naked seeds only 0.19 gm. If the environment becomes suddenly dry, the pod protects the seed from excessive siccation.

When the radicle has developed, it suffers less from dryness in unhusked seeds than in the husked seeds: thus in two lots of 27 seeds each, 10 and 21 radicles respectively were injured. With a return of humidity, even seeds which had their radicles destroyed could protect themselves by sending out fresh lateral roots.

From the above it follows that the pod performs complex functions: it not only favours a wide distribution of the seeds owing to its conformation (wings, prickles, hairs, etc., which, however, vary much in different species of *Onobrychis* and also in varieties), but also forms a mechanical protection to the seed which it covers, and stores moisture which helps the growth of the seed; the seed enveloped in its pod absorbs moisture and swells more slowly, but more surely.

The pod equalises the variations of humidity in the environment; sudden differences are borne by the pod, while the seed only feels their mitigated effect. The moisture which is collected through the pod and passes into the seed, serves the latter specially when it grows under dry conditions in the soil.

This behaviour throws light on some vicissitudes in the growth of peas, especially in southern, dry regions, where, it often happens that the seedling, especially if sown in spring and in ground which dries up easily, can only benefit by a single fall of rain, some times even a very slight fall, and that followed by a prolonged drought. The difficult period for plants of this kind is almost always the beginning of the development of the seed, because when in full growth the plant no longer suffers from the dryness of the soil. Now it is precisely at the critical period of need of moisture, however slight, that the function of the pod is useful, for it stores up a greater amount of moisture than the husked grain could absorb and gives it up to the seed later. Furthermore it prevents, in the period which precedes germination and at the beginning of the period which follows it, a sudden and rapid loss of moisture by the seed, when the conditions of environment become suddenly and markedly dry; lastly it is sometimes useful in retarding germination until the conditions of humidity improve, while the husked seeds which have already germinated perish.

Such are the reasons why, while meadows sown with husked seed do not succeed, especially if the dry season hinders the first development of the seed, the chance of the meadows is more certain when the seed has

t been husked: this the writer has been able to prove in a series of experiments in the open field, and therefore concludes that it is not advisable to husk the seed.

L. V.

3 - Absorption of Ions of Aluminium through the Root System of Plants. —

STOKLASA, J. in collaboration with SEBOR, J., TYMICH, F. and GWACHA, F. (Biochemische Abteilung der Staatl. Versuchstation an der böhmischen technischen Hochschule, Prag) in *Biochemische Zeitschrift*, Vol. 128, Nos. 1-3, pp. 35-47. Berlin, March 7, 1922.

The absorption of aluminium was studied for the first time by the Russian physiologist W. ROTHERT, in collaboration with BOROWIKOW and HIMKINE: all the plants tested absorbed the element, which was furnished in the form of soluble compounds and even certain insoluble compounds. These researches were followed by those of the writer, of BERTRAND, AGULHON and SZÜCZ.

At present the author has undertaken the analytical study of the problem, using aqueous solutions: he employed a mineral solution of definite composition in which he plunged the roots of young robust plants after careful washing. The aluminium was added in the form of sulphate and control cultures were not neglected. The writer has experimented with hydrophytes, two mesophytes and two xerophytes.

In a preliminary experiment the sulphate of aluminium was used at a strength of 0.001 gm-atom of aluminium per litre of solution. The xerophytes and several of the mesophytes developed badly. For the analyses, made after 26 days, the writer chose the most healthy samples. All the plants absorbed much aluminium, especially the hydrophytes; the mesophytes absorbed less and the xerophytes still less. The greatest amount of aluminium was found in the roots.

By increasing the concentration of sulphate of aluminium 15 times (0.015 of the atomic weight of aluminium expressed in grammes, per litre of solution), all the plants died: first of all the xerophytes in 7-11 days; then the mesophytes beginning from the 17th day; lastly the hydrophytes as from the 23rd day. The proportion of aluminium absorbed was much less in this than in the previous experiment: aluminium was absorbed to the greatest extent when the solutions were weaker: it is therefore clear that it is not a simple diffusion which takes place, but that a *specific* permeability of the rhizome is produced, associated with phenomena of absorption and reactions which develop in the intracellular colloids. The aluminium which has penetrated into the cells causes contraction of the protoplast; then, if in strong concentration, it softens and dissolves it (STOKLASA, BERTRAND, AGULHON, SZÜCZ). In the xerophytes, this plasmolysis is more rapidly accomplished; more slowly in the mesophytes and only with strong concentrations in the hydrophytes. The degree of reversibility of the process is conditional on the concentration of the ions of aluminium and on the duration of their action.

Hydrolysable compounds of iron, manganese, copper, etc., show themselves still more toxic than those of aluminium; compounds of aluminium can even reduce their poisonous effect, because they take the place

of others in the cells, which causes an exchange and a new balance of cations.

The writer had previously noted this protective action of aluminium but he has now made a more complete study. He selected, with this object, the three species of plants, which in his previous experiments had absorbed the largest amounts of aluminium and he put them to grow in four mineral liquids of identical composition, but one of which being without aluminium or iron, served as control; another contained aluminium; a third contained iron; a fourth both these elements. In the second and third of these nutrient liquids, the absorption of aluminium and of iron were accompanied by an abundant elimination of magnesium, calcium and sodium; that elimination was however, much more marked in the liquid containing iron, evidently because iron exercises a more intense toxic action than aluminium and consequently kills and dissolves the protoplasts, setting free almost all the salts. In the liquid which contained iron and aluminium, the latter diminished the penetration of the iron and, consequently reduced the harmful action; it prevented plasmolysis and limited the loss of mineral principles. The analysis of the plants grown in the four liquids showed that the addition of iron alone sensibly reduced the total ash content while the addition of aluminium and of aluminium and iron increased it, while reducing the content of potassium, sodium and phosphorus.

The three plants studied are plants of peat bogs: they therefore grow well in relatively acid media and are not tolerant of bases. The author has remarked that very many cryptogams behave similarly. He gives the analyses of some of these plants: — ferns, lycopods, horsetails, etc.; their ash is rich in silica, aluminium, iron and sometimes in lime; it is probable that they have adapted themselves to this kind of mineral exchange from the remotest time; it suffices to consider that most coals were formed by these hygrophytes, which utilise the most common mineral elements in the soil: — silica, iron and also sulphur (ferrous and ferric sulphates); it is probable that aluminium had already the power to neutralise the injurious action of iron present in the ground in the form of oxides and hydrates and especially of ferrous and ferric sulphates; it thus limited the absorption of potassium and phosphorus in which, as a matter of fact, coals are poor.

L. V.

814 - Experiments on the Use of Artificial Light in the Growth of Plants. in Germany. — HÖSTERMANN, in *Verein Deutscher Ingenieure*, Vol. XVI, No. 21, pp. 521 Berlin, May 27, 1922.

The first experiments on the use of electric light for inducing the growth of plants were made in 1880 by Wilhelm SIEMENS, with a 1600 candle-power arc lamp; these experiments were next reproduced at Bromberg by means of arc lamps and mercury lamps with unsatisfactory results on the other hand experiments made in England and Ireland in 1919 by TJEHRES and UTHOFF induced an increased yield up to 50 %. In the buildings of the Experimental Station of plant physiology at Dahlen (Germany)

periments were made during the winter of 1921-22, to ascertain the influence of artificial light on the growth of plants in glass frames; in winter, in a heated place, the difference of growth of plants, compared with the summer, is determined not only by the temperature and by the manuring which may be the same at both seasons, but also by the duration of daylight; in fact, it is the light absorbed by the chlorophyll which furnishes the energy required for the reduction of carbonic acid into carbon, from which carbohydrates are produced through assimilation. But it is not only daylight which exercises a beneficial action on the process of assimilation; this action can also be exercised by light coming from another source, provided that it is comprised in the category of wave lengths in the compass of which the colouring matters of the leaves have a power of absorption. The question is to select the light which will give the best return.

According to what can be deduced from researches on the physiology of plants, with a luminous intensity of about 1000 Lux, the assimilation may be considered as proportional to the illumination, while, with a more intense light, assimilation is less and less accelerated and this is why artificial light was not used simultaneously with the winter light, but the day's light was prolonged from dusk by means of an electric current.

Over a plot 5 m. long by 1.50 m. broad were arranged 5 "Nitra" lamps of 200 watts, in such a way that the light could be diffused as uniformly as possible; the lamps were placed 0.70 m. from the edge of the lot, at a distance of 1.20 m. from each other at a height of 0.60 m. above the plot, and were furnished with WISKOTT reflectors. The intensity of the illumination of the plants varied over different points of the surface of the plot from 300 to 900 Lux, and was exactly 900 Lux under the lamp and 300 at the edge of the plot. The daily consumption of electric power by the lamps, lighted for about 6 hours every day commencing at dusk, amounted to 4.8 kilowatt-hours for lighting a surface of 7 sq. m. Forced cultures were made on that surface; the preceding period of vegetation of some of them had already made it possible to have an idea of the principles assimilated; others, having just germinated had still to construct their vital elements. Close to the plot of illuminated plants was the control plot, with the same plants and separated from the former by a partition of white wood; this plot, except for light, received the same care as that of the illuminated plants.

Cabbage-lettuces, illuminated from mid-November, had after 12 days on an average about two and a half times as many fresh leaves as those not illuminated; moreover, the leaves of the former were larger and firmer, so that after 18 days the plants had developed like lettuces sold at 2 marks each. Plants exposed only to daylight required from 4 to 5 weeks, or double the time to attain this degree of development; it would therefore be possible, in practice, to obtain in the same period of time two crops of lettuce instead of one. In 18 days the consumption per lamp was 21.6 kilowatt-hours; the price at the time of the experiment being 1.20 mark per kilowatt-hour, it cost 26 marks for illuminating a surface of 1.2 sq. m. But as (with a doubled crop) 480 marks instead of 240 is drawn from a

surface of 1.2 sq. m., there remains, at this price of electric current, a surplus gain of 214 marks per 1.2 sq. m.

To examine its subsequent growth, the lettuce was left in its place since it did not flower but continued only to grow. However this vegetable probably, should not be attributed to lack of power of the electric light relatively to solar light, but more especially to the richness of the artificial light in red rays, compared with daylight. The crop was gathered after 7 weeks of prolonged illumination; a comparison was then made between the plants of the illuminated plot and those of the plot not illuminated: a superiority of weight of the former over the latter of 50% in the green state and 68% in the dried was found.

The effect was equally good on beans and vetches. *Lathyrus odoratus* grew much more vigorously under the influence of the illumination and it flowered earlier and more abundantly. Strawberry plants illuminated yielded, as early as the middle of March, very sweet and scented fruit while those not illuminated were 4 weeks later. The favourable effect of electric light in the prolongation of the short daylight from November to May, was very clearly shown on all greenhouse crops and especially on lilac which gave very fine inflorescences under this treatment, with more intense perfume and brighter colour. But certain data are lacking regarding:— 1) the most correct and suitable illumination for certain species of plants; 2) the duration of illumination; 3) the most favourable colour of the light; hence without exact knowledge of the sources of light and of the physiological effects of the light, it is not yet possible to form a correct judgement.

P.

815—Influence of X-rays on dry seeds and germinating seeds. — PETRY, E. (Zentrabl. d. Botanischen Institut des Landeskrankenhauses Graz), in *Biochemische Zeitschrift*, Vol. 121 Nos. 1-6, pp. 326-353. Berlin, March 28, 1922.

G. SCHWARTZ has already stated that dry seeds stand, without damage, to an intense application of X rays up to 40 times as strong as those to which germinating seeds show themselves sensible. The writer has noted also that, even when respiration is lessened, for example by means of cyanic compounds, sensibility to X rays continues. He has now observed that a rapid hydration of dry seeds or of dried germinating seeds was sufficient to stop or renew this sensibility, which is therefore due to the water and, in this respect, may be compared with the sensibility to heat, ferments and proteins. But the water acts not only as such; it causes also the chemical changes inherent to germination: in fact, if the supply of oxygen is suppressed, and germination is thus hindered, sensibility to X rays decreases; on the other hand, germinating seeds which have been dried are always much more sensitive to X rays than dry seeds. Chemical changes therefore intervene which modify the environment; they may consist in the stimulation of the proferments, in hydrolytic splitting up of reserve materials, in oxidising processes, in processes of assimilation and breaking-down. Notable differences are remarked with different seeds; for example, seeds of leguminous plants are much more sensitive to X rays than the seeds of cereals.

L. V.

316 - **The Applicability to the Problems of Plant Genetics of Morgan's Theory of the Mechanism of the Chromosomes.** — JONES, D. F., in *The American Naturalist*, Vol. LVI, No. 645, pp. 166-173. Lancaster, P. A., April 1922.

The data so far collected are sufficient to justify the supposition that the chromosome theory postulated in the case of *Drosophila* is equally applicable to plants. The pea, primrose and maize have all furnished excellent material for studying the linkage of genetic factors in the plant world. Owing to the ease with which maize can be cultivated the large number of grains it produces, and its great variability from the genetic standpoint, this plant has been the special object of investigation.

Owing chiefly to the work of EMERSON and his school it has been possible to distinguish in maize 6 groups of linked factors, and in the case of most of these factors their relative position in the chromosome has been determined. Therefore from the study of the genetic phenomena in this plant an indirect proof of the mechanism of the chromosomes has been obtained.

If two families are taken that have been long enough self-fertilised to have become almost, if not quite, homozygous, on crossing an absolutely uniform F_1 is obtained. This is then repeated with two further families and another F_1 is produced. When this point has been reached, the work is carried on in two directions: 1) the two F_1 generations are crossed together and produce $F_1 \times F_1$, a double hybrid of the 2nd generation; 2) an F_2 is obtained by the self-fertilisation of the F_1 . Each line of maize so far produced by self-fertilisation has hitherto always been found to differ in many of its characters from any other line no matter whether it is descended from the same variety or from a different original variety. The self-fertilised lines when crossed show a remarkable increase in growth and, if again selfed, a rapid decrease in vigour, together with greatly increased variability in the following generations.

It may therefore be assumed that the greater number of self fertilised lines differ from one another as regards many of the genes in each chromosome. If this be the case, the double combination $F_1 \times F_1$ should have a much more complex structure than the F_2 , and a critical comparison of these double hybrids with the hybrid parents of the first generation and with their F_2 by self-fertilisation, if based on the variability of their different characters, ought to afford some indication of the distribution within the chromosome of the genetic factors influencing growth. As regards the other factors, the variability of the double hybrid should be almost the same as that of the 2nd generation obtained by self-fertilisation, though in the characters which are in direct connection with the vigour of the plant, the double hybrid ought to resemble the F_1 , which has lower variability coefficients. To decide these questions, the following characters were investigated: number of rows of grain per cob; the nodes of the plant; the height of the plant; length of the cob; grain production, the weight of the whole female fructification with its ripe grains.

The preliminary study of the 1st generation resulting from the cross of two self-fertilised lines of maize showed that the number of rows of

grain in the hybrid was 5.29 % larger than in either of the parents. As regards the other characters, the percentage increase observed was as follows:

Number of nodes per plant	6.43
Height of plant	27.44
Length of cob	28.57
Total grain yield	180.00

The vigour of the plant therefore has much less effect upon the number of rows and of nodes than upon other characters, especially grain production. Assuming the vigour of the hybrids to be due to the complementary action of the dominant factors, the combination $F_1 \times F_1$ (the double hybrid), if the factors essential to growth are numerous and distributed uniformly through the chromosomes, ought to be *less variable* than the F_2 obtained by self-fertilisation. On the other hand, characters that are entirely or almost independent of growth vigour (number of rows of grain and number of nodes), should present almost the same variability as the F_1 .

The data given in the annexed Table confirm this hypothesis. The variability of the families $F_1 \times F_1$ as regards the number of rows and nodes is almost identical with that found for the F_2 families. On the other hand, in all that concerns the characters in correlation with the vigour of the plant, the families of the $F_1 \times F_1$ show a decreased variability. Further, the fact that all the plants are uniformly vigorous and that their high averages are not to be attributed to the presence of some individuals of exceptional development, proves indirectly that the hereditary factors which control the growth of the plants are very numerous and distributed widely through all the chromosomes, or at least a large number of them.

From the point of view of improving maize, it certainly would be most desirable that all the factors which control the superiority of a hybrid over its parents should be present in a homozygous condition in a single individual. The latter would be in a more stable condition than an individual possessing heterozygous combinations of the factors in question, given that the factors determining growth vigour rarely attain to complete dominance. The recombination of the linked factors is a problem deserving the most careful attention of those interested in genetics. In any case, linked factors are not two paired factors present in the same chromosome but two factors situated in the same chromosome at a distance from one another of less than 50 units. When the distance between the two loci is 50 length units (1) or more, factors situated in the same chromosome at a greater distance apart are as independent of one another from the point of view of transmission, as if they were in different chromosomes. The number and arrangement of the genes themselves therefore appear to be of

(1) By 1-2-3 etc., units of length is understood 1-2-3 etc. % of the crossing over. Thus, in the case of two linked characters with a crossing over percentage of 24, it would be said that their genes are situated in two loci of the chromosome 24 length units apart. (Ed.)

reater importance than the number and arrangement of the chromosomes. When each gene is independent of all the others situated at a distance exceeding 50 units and therefore behaves according to Mendel's law, the author proposes the term of *mendel* for a chromosome segment of a length equivalent to 50 % of the crossing-over.

Comparative data showing the variability of the 1st generation, of the double 1st generation and of the hybrids of the 2nd generation.

(CV = Variability coefficient; PE = probable error).

	F_1		$F_1 \times F_1$		F_2	
	CV	PE	CV	PE	CV	PE
no. of rows of seed	8.90	0.40 - 0.98	12.76	0.52 - 0.65	12.31	0.45 - 0.82
no. of nodes per plant	5.54	0.25 - 0.78	5.88	0.25 - 0.27	6.20	0.26 - 0.33
height of plant . .	7.06	0.25 - 1.04	6.20	0.25 - 0.33	6.92	0.26 - 0.40
length of ear . . .	13.83	0.72 - 1.66	13.23	0.41 - 0.75	16.90	0.69 - 1.03
Weight of seeds . .	24.13	1.15 - 1.42	26.99	1.19 - 1.44	32.68	1.11 - 2.31

G. A.

317 - Genetic Selection of the Wheats " Bianchetta " and " Gentil rosso ", at Andria in Apulia (Italy). — VIVARELLI, L., in *La Propaganda Agricola*, 2nd Series, year XIV No. 1, pp. 1-15; No. 2, pp. 27-31, 2 figs. Bari, Jan. 1922.

Genealogical selection of the wheats " Bianchetta di Puglia " and " Gentil rosso " begun in 1916.

The work was done in three stages:—

1st year: Selection of ears as founders and starting of pure strains.

2nd year: Comparative test of the descendants of these ears.

3rd and following years: Multiplication and propagation of the selected plants.

In the course of these experiments the following characters were specially considered; number of stems; number and length of internodes; average quotient; length of ears; large or small number of leaves; intensity of colour; time of ripening; resistance to lodging and rust, etc.

Among the numerous families thus isolated, the following 4 deserve special attention: — 1) " Bianchetta " fam. A.; 2) " Gentil rosso " fam. A.; 3) " Gentil rosso " fam. B.; 4) " Gentil rosso " fam. C. To give an idea of the effect of selection on the morphological and physiological characters the following comparative data relating to unselected " Bianchetta " and " Bianchetta " of the fam. A, are given.

In the average proportion or biometric value of the grain $\frac{L}{D}$, L represents the length and D the maximum diameter of the grain, placed groove downward. This proportion indicates that the grain of the selected variety tends sensibly to elongate.

	« Bianchetta » common	« Bianchetta » fam. A
Average height of the plants, in cm. . . .	92	120
Average length of the ears, in cm. . . .	8.5	14.5
Average number of grains per ear	23	40
Weight of grains of 100 ears, in gm. . . .	101	246
Average proportion, in gm.	1.90	2.00
Average quotient, in gm.	0.32	0.20
Aborted spikelets at the base of the rachis.	4	2
Stalks and ears per plant	2-3	6-8

In the average quotient or biometric value of the stalk $\frac{S}{R}$, S represents the thickness of the wall of the stalk in the middle part of the mean internodes and R the radius of the cavity.

This proportion indicates that the stalk varies in length but that the thickness varies little; there is therefore no reason to fear that the feeding qualities of the straw might decrease by selection, nor that it might become weak and liable to lodge.

The difference in favour of the selected families (see Table below) shows clearly and it has been maintained throughout the three years of the experiment, in spite of great variations in meteorological conditions during the same period.

*Production of grain and straw during the triennial period 1919-1921
(in quintals per hectare).*

	1919		1920		1921	
	Grain	Straw	Grain	Straw	Grain	Straw
« Bianchetta » common	7.20	10.70	8.00	12.40	7.50	—
» fam. A.	9.80	16.30	12.10	19.30	11.50	—
« Gentil rosso » fam. A. . . .	8.50	15.80	10.30	16.20	12.30	—
» » B.	9.60	17.10	11.80	18.40	—	—
» » C.	12.30	19.80	12.50	20.10	—	—

G. A.

818 - **Natural Hybrids of Wheat Rye at Saratov (Russia).** — MEISTER, G. K., in *The Journal of Heredity*, Vol. XII, No. 10, pp. 467-470. Washington, December 1921.

In 1918, a well authenticated and unusual occurrence was seen at the Agricultural Experiment Station of Saratov (Russia) viz., the existence of a large number of natural hybrids (in the F_1) between wheat and rye.

These hybrids made their appearance in some plots sown with winter wheat: *Triticum vulgare* v. *erythrospermum*, v. *Hortianum* and v. *pyro-*

thrax. The number varied in the different plots; sometimes they were entirely absent, or very rare; in other plots, they occurred in considerable quantities; plot No. 828 sown with var. *erythrospermum* contained 20 % of the hybrids, while their total number reached several thousand.

The plots containing the largest number of these hybrids were characterised by their early ripening, so that the flowering phase coincided with, or at least overlapped, the flowering phase of the rye. The glumes of these varieties of wheat are very widely open and far apart at the flowering season which facilitates cross-pollination. Owing to the continental, dry climate of Saratov and its low rainfall (about 380 mm.), crosses between different varieties of wheat are of practically habitual occurrence.

In 1917, the year preceding the appearance *en masse* of the wheat \times rye hybrids, the season had been drier than usual.

The hybrids in question belong to the F_1 , and occupy an intermediate position between *Secale* and *Triticum* with a slight predominance of the characters of *Triticum*. In general habit, the plant is more like wheat than rye; in most of the culms however the upper part of the rachis near the base of the ear is hairy, as is the case in rye.

The seed of the first year (F_1) produced 209 plants and these may be divided into 4 groups:

I) Two individuals of the *Secale* type with a tendency to self-pollination.

II) 87 individuals of the *Triticum* type. In these, frequent morphological traces of *Secale* were noticeable: buds coloured by anthocyanin — elongated glumes — keel-shaped glumes, etc.

III) 12 plants of entirely new type with long ears and glumes, and a large number of spikelets. In these forms, the rye characters were predominant although the grains were typical wheat grains.

IV) 102 plants of intermediate character.

As regards fertility: 29 of the plants were completely sterile; 42 % had only one grain each; 11 % were normally fertile 18 % occupied an intermediate position.

Among the hybrids, new characters, quite different from the characters of either parent, made their appearance as for instance: narrow pointed leaves resembling the leaves of certain wild *Gramineae*; thick leaves; very brittle rachis; very rough awns culms; with thick walls. In the 3rd and 4th generation, there are typical wheat and typical rye individuals with very few intermediate forms.

When this point was reached it was useless to continue the analysis.

The chief fact to be learnt from the examination of the data collected is that the characters of the hybrids of the first generation, whether the latter are of the typical wheat, or rye, type (or even intermediate), remain fixed in the succeeding generations.

The following question may now be asked: since in the segregation processes there is a clear distinction between the two fundamental forms *Triticum* and *Secale*, what are the characters regulating their resistance to low temperatures? If it be conceded that opposite morphological

characters exist, surely the presence of similarly opposite physiological characters cannot be denied.

As regards the resistance to *Fusarium nivale* evinced by wheat \times rye hybrids, distinct segregation has been observed resulting in their division into very resistant and highly susceptible families respectively. This indicates the possibility of obtaining resistant types by means of crossing and selection.

The low temperature resistance of some families of the rye type was found to have diminished, as if they had been forfeited as a result of taking on certain wheat characters.

On the other hand, many of the hybrids of the *Triticum* type showed increased resistance to cold. G. A.

819 - A Study of the Hybrids, Red Rustproof (*Avena sterilis*) \times Black Tartarian (*Avena orientalis*), in the United States. — WAKABAYASHI, S., in *Journal of the American Society of Agronomy*, Vol. 13, Nos. 6-7, pp. 259-266, Washington, October 1921.

This paper gives the results of experiments on the inheritance of resistance to smut (*Ustilago leavis Avenae*), sterility, panicle shape, colour of glume, and correlations among these characters in the F_2 and F_3 of Red Rustproof (*Avena sterilis*) \times Black Tartarian (*Avena orientalis*).

TABLE I. — Comparison between the chief characters of the two Parents.

Characters	Red Rust proof	Black Tartarian
Average height, inches	32	23
Average number of culms per plant . . .	8.3	2.3
Average number of kernels per panicle . .	45	169
Susceptibility to smut	Immune	Susceptible (av. 34%)
Percentage of sterile flowers	25	14
Shape of panicle	Pyramidal	One sided
Average length of panicle (in ches) . . .	5	11

The most important results obtained may be summarised as follows:

I. — SMUT RESISTANCE. — Red Rustproof has never shown a single indication of smutting, whereas the percentage of rust infected Black Tartarian plants ranged from 25 to 40. The F_1 and F_2 have never shown a trace of smut. In the F_3 , there were 12 infected lines, while 95 remained immune. In the 12 infected lines, the percentage of diseased plants was 15 — 12 — 9 — 8 — 4 — 4 — 4 — 3 — 3 — 2 — 2 — and 0.1 respectively, thus the most susceptible row produced less than half as much smut as the susceptible parent.

The cause of immunity up to the F_2 and the pronounced resistance in the F_3 indicate the existence of multiple factors. Since the susceptible parent showed smut on less than half the plants, the behaviour of the F_3 is nearly what is to be expected if the immunity of Red Rustproof

is caused by 3 independent dominant factors any one of which would prevent the appearance of *Ustilago*.

The fact that resistance is dominant is unusual, inasmuch as it has been reported recessive in wheat yellow rust (BIFFEN and NILSSON-EHLE) and in stinking smut of wheat (GAINES).

II. — STERILITY. — The record shows Red Rustproof to be higher in sterility than Black Tartarian. Their crosses are comparatively high in sterility, although this sterility decreases in successive generations because the sterile strains eliminate themselves. Great differences were observed between one panicle and another, some being 100 % sterile, while a few were less than 5 % sterile.

Table II shows the sterility in the parents and the F_1 , F_2 and F_3 . It proves the progressive decrease of sterility in the successive generations when averaged, but the increased fertility of some of the F_3 rows suggests multiple factors and is of economic importance.

TABLE II. — *Comparative Sterility of Red Rustproof and Black Tartarian oats and their Hybrids of the First Three Generations.*

Variety	Number of fertile flowers	Number of sterile flowers	Sterility percentage
Red Rustproof	454	112	25
Black Tartarian	1 452	246	14
Red Rustproof × Black Tartarian F_1 . . .	122	197	62
" " F_2	2 802	3 663	57
" " F_3	39 721	23 935	38
Black Tartarian × Red Rustproof F_1 . . .	68	167	71
" " F_2	1 158	620	35

III. — COLOUR OF THE GLUMES. — Red Rustproof has white glumes slightly tinted with red (**bb**); Black Tartarian has dark brownish or black glumes (**BB**). It is difficult to distinguish **Bb** from **BB**. If, however, the two classes are combined, the proportion is 72 % of plants with coloured glumes and 28 % with white, which approaches the monohybrid ratio 3 : 1.

IV. — SHAPE OF THE PANICLE. — The author spent much time in trying to classify the F_3 and F_2 panicle types segregating in 1919, but owing to the rapidity with which the material ripened and the changes produced by different stages of maturity, the classification was unsatisfactory. It was, however, sufficiently accurate to show that the inheritance of the asymmetrical or horsemane type of panicle is recessive, but produced by multiple factors.

V. — DWARFNESS. — In most cases, plants which were below 24 inches in height were counted as dwarf. The production of dwarf plant was interfered with by sterility, and it is therefore difficult to state whether it is a simple Mendelian character.

TABLE III. — *Correlation between Colour of Glumes, Shape of Panicle and Height of Plant.*

Black asymmetrical panicle		Black pyramidal panicle		White asymmetrical panicle		White intermediate panicle		White pyramidal panicle	
No. of plants	Height in inches	No. of plants	Height in inches	No. of plants	Height in inches	No. of plants	Height in inches	No. of plants	Height in inches
I	15	I	70	I	45	3	50	I	45
I	40	—	—	2	50	—	—	I	67
I	45	—	—	2	55	—	—	—	—
I	60	—	—	I	65	—	—	—	—
I	67	—	—	I	67	—	—	—	—

VI. — CORRELATION. — Table III classifies the smutted oat plants according to colour of glumes, shape of panicles and height.

There seems to be some correlation between dwarfness and sterility, and between smut susceptibility and dwarfness. There may also be a correlation between smut susceptibility and the white colour of the glume, and between susceptibility and asymmetrical panicle.

Sterility is not correlated with the colour of the glume or the shape of the panicle.

G. A.

820 — *The Improvement of Sorghum by Crossing and Selection in the United States.* — VINHALL, N. N., and CRON, A. B., in *The Journal of Heredity*, Vol. XII, No. 10, pp. 435-443 + figs. 6. Washington, December 1921.

Until recently, all the studies on the hybridisation of sorghum in the United States have been confined to the subject of natural hybrids. Now, however, that the separation and isolation required to obtain pure lines is finished and the pure lines have not proved as satisfactory as was expected, the investigators are persuaded of the necessity of having recourse to crossing, if any further improvements are to be attained.

In the hybridisation experiments carried out by the Office of Forage Crop Investigations in greenhouses in Washington, and in experiment fields at Amarillo (Texas), the following system is adopted.

1st *Generation.* — The grain obtained by cross fertilisation is sown in rows and the F_1 plants bagged to prevent the access of foreign pollen.

2nd *Generation.* — The grain produced by the F_1 plants is sown in rows. The best plants of the F_2 are chosen when they are well developed and their inflorescences are isolated in order to carry out comparative tests with their parents and other commercial varieties.

3rd *Generation.* — The grain of chosen individuals from the F_2 is sown in rows, one row being reserved for each plant (Head to row). The best individuals of the F_3 are chosen out and isolated, enough seed being taken if possible to sow a whole experiment plot next year. When the rows are very uniform they are regarded as units.